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TABLE OF CONTENTS.

ENGINEERING NEWS OF THE WEEK..... 129
Reservoir No. 5, Boston Water-Works (illustrated). 130
Some Open Questions Concerning Structural Steel. 131
Locating Obstructions in Underground Pneumatic Tubes in Philadelphia (illustrated)..... 132
Recent Designs for Steel Cars, Universal Construction Co. (with full-page engraving and other illustrations) 134
The Report of the Steam Users' Association..... 135
The Siberian Railway Extension in China..... 135
Weather Report for January..... 135
A New Formula for So Locating Two-Plate Girders Relative to a Curve as to Bring Equal Loads to Each 139
Removal of Paint from Iron and Steel Surfaces by the Sandblast 139
Test of Pohle Air-Lift Pumps at the Rockford, Ill., Water-Works (illustrated)..... 140
Diagram for Estimating the Required Storage Capacities for River Drainage Areas (illustrated).. 141
Concrete Sidewalks in San Francisco..... 141
Smoke-Stacks and Front-Ends for Locomotives Burning Lignite and Wood Fuel (illustrated).... 142
Book Reviews 143
EDITORIAL NOTES 136
An Appropriation for Further Nicaragua Canal Surveys—The Need of Honesty in Public Land Surveys—The Proposition to Abandon Cable Traction on the Brooklyn Bridge.
EDITORIAL:
The Improvement of the Apprenticeship System as a School for Mechanics..... 136
LETTERS TO THE EDITOR 138
Rainfall on the Pequannock, Croton and Sudbury Drainage Areas, 1892 to 1895—Weir Tables for Measuring Water for Irrigation—The Business Chances of Engineering Graduates—A Restriction of Interstate Commerce—Concerning the Public Land Surveys.

THE NEW PANAMA CANAL COMPANY proposes to lay before an international board of engineers the project as now decided upon. This plan calls for a summit level with its bottom 34 m., or 111.5 ft. above mean sea-level. There would be five locks on each slope, with a maximum lift of 33 ft. The flow of the Chagres River is to be regulated by a great storage reservoir built above the level of the canal and a lake in the valley at Bohio formed by damming the outlets, and provided with a special discharge waterway. The ship canal would be fed from the Chagres reservoir through a special canal, about 9 miles long, leading to the upper level. The level of the water in this upper Chagres reservoir will be maintained at about an elevation of 197 ft. above the sea, thus providing a fall of about 50 ft., which will be utilized for hydraulic power. The locks are to be in pairs, and will have a clear length of 650 ft. and a width of 82 ft. for one and 59 ft. for the other lock. The general width of the new canal will be 25 m., or 82 ft., on the bottom and 50 m., or 164 ft., at the water surface; but this will vary with local conditions.

THE NEW DISMAL SWAMP CANAL may be completed by Jan. 23, 1898. The enlarged canal was commenced in March, 1896, by a Baltimore syndicate, formed, in 1895, by Alexander Brown & Sons, which provided $1,200,000 in construction and equipment bonds for this purpose. The old canal was about 26 miles long, 32 ft. wide on the bottom, and carried a minimum depth of 4 ft. It had five locks, and would pass barges 100 ft. long, 16½ ft. wide and drawing 3 ft. The new canal will be 40 ft. wide at the bottom, 60 ft. wide at the water surface and have a minimum depth of 10 ft. Two locks, one at each end of the canal, will replace the five old locks; and each of the new locks will be 250 ft. long, 40 ft. wide, and have 10 ft. of water over the mitre-sill. Ten turn-outs are also to be provided. It is estimated that a speed of 10 miles per hour can be maintained in the new canal, and the 50 miles between Norfolk and Elizabeth City can be covered in 6 hours by barges towed by tugs; and fast river steamers can cover the distance in four hours. If this be true the new canal will be a powerful river to the present Albemarle & Chesapeake Canal.

NEW ORLEANS DRAINAGE WORK, to the extent of $900,000, has been determined upon and recommended by Major B. M. Harrod, Engineer of the works, in his late report to the Drainage Board. This includes the Metaire Ridge Pumping Station, with approved canals, to cost $124,707, and the enlargement of the Claiborne, Dublin Avenue, Seventeenth and Upper Protection canals, costing altogether about $201,037. The estimated cost of the work already planned and acted upon by the Drainage Board amounts to $900,030.

THE SUPERIOR-DULUTH HARBOR WORK calls for the removal of about 21,000,000 cu. yds. of material by dredging, says the "Telegram," of Superior, Wis. The same journal states that owing to underbidding for work in Boston harbor, there was a declaration of war between the American Dredging Company, of Philadelphia, and the Toledo dredging companies. The government engineers' estimate for the work, at 15 cts. per yard, was $3,150,000. As a result of the competition, Capt. C. S. Barker, of Superior, and Williams, Green & Upham, of Duluth, bid 7½, 8 and 10 cts. per yard, the bids for the three districts aggregating $1,665,645; the Rooney bid, from Detroit, was $2,229,842; the Brayman bid was $2,275,782, and the American Dredging Co., of Philadelphia, underbid its two latter rivals with a gross bid of $1,986,100. The "Telegram" says that had the American company succeeded in obtaining the work it proposed to establish an extensive and permanent dredging plant upon the Great Lakes. The lake dredgers realized this and in the effort to check this threatened competition made the low bids which surprised the government engineers. The work let includes the deepening the harbor to a uniform depth of 20 ft., and the widening of the channel to 400 ft. The difference between the sum available and the actual bids is about $1,300,000, and it is reported that with this sum Maj. C. B. Sears, Engineers' Corps, U. S. A., proposes to advertise for other bids to widen and deepen the 400 ft. channel, and build new piers. Among the unsuccessful bidders was Mr. A. P. Bowers, of San Francisco, the inventor of the hydraulic dredge. It is said that the successful bidders propose to do much of the work with the "clam-shell" type of dredge, and they have yet to secure or build the 20 dredges estimated as necessary to complete the work in four years.

THE WHITE STAR STEAMSHIP "OCEANIC," now contracted for with Harland & Wolff, of Belfast, will be the longest vessel ever built. As designed this twin-screw passenger steamer will be 704 ft. long and will measure 17,000 gross tons. She is to be capable of crossing the Atlantic in six days, in any weather; but the full details of her construction are not yet made public. As compared with other large vessels the record stands about as follows: "Great Eastern," 679½ ft. long on water line and 691 ft. long over all; beam, 83 ft.; depth, 48 ft.; registered tonnage, 18,915 and 32,160 tons displacement. The "Lucania" and "Campania," of the Cunard Line, and the next longest ships, are 620 ft. long, 65 ft. beam, 37 ft. depth of hold and measure 12,950 gross tons. The "Majestic" and "Teutonic" are 582 ft. long, 57 ft. 8 in. beam, 39 ft. 4 ins. deep, with a measured cargo space for 4,270 tons. The "Georgic," also of the White Star Line, is 500 ft. long, 60 ft. beam, 36 ft. deep and has a gross tonnage of 10,150 tons, and a net tonnage of 6,570 tons. The freight carrier, "Pennsylvania," of the Hamburg-American Line, is 585 ft. long, 62 ft. beam, 42 ft. deep, 23,400 tons displacement and 13,500 tons dead weight.

THE REMOVAL OF BRIDGE PIERS in the Ohio River and Monongahela River has been ordered by the Secretary of War, on the ground that they are unreasonable obstructions, and notice to this effect has been given by Maj. W. H. Heuer, U. S. Engineer Corps. The order will require the removal of obstructing piers of the Bellaire, Steubenville and other bridges in the Ohio and Monongahela Rivers, and will compel the owners to change the piers by March 17, 1898. It is proposed to remove the channel pier of the Steubenville bridge and reconstruct the bridge so as to lengthen the channel span. It is proposed to remove the channel span of the Bellaire bridge on the West Virginia side, and reconstruct the bridge so as to lengthen the channel span. A board of U. S. Engineers will inspect the structures mentioned. The bridge people, it is expected, will offer considerable opposition to the proposed changes, but it is said that the bridges at Bellaire and Steubenville are the worst obstructons to navigation on the Ohio, and have cost the coal men large sums of money in the coal barges that have been sunk by them.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a grade crossing collision at 103d St., Chicago, on the Chicago & Eastern Illinois R. R., Feb. 25. An electric car got beyond control and ran through the crossing gate, reaching the middle of the railway tracks just as two trains were passing, so that it was struck by both trains. Three persons were killed and two were fatally injured.

A BOILER EXPLOSION occurred Feb. 27 at the Acushnet Mills, New Bedford, Mass., wrecking the boiler house, harness shop and cloth room. Two men were killed and five were badly hurt, while a number were cut and bruised by the flying debris. The engineer claims that he was in the boiler house only ten minutes before the accident, and that the gages showed 93 lbs. pressure, the safety valves being loaded for 94 lbs. pressure.

A BREAK IN THE NEW LAKE TUNNEL at 68th St., Chicago, occurred Feb. 22, and the 48 men in the tunnel had barely time to escape up the shaft at the crib. The water had been leaking in considerable quantities, and finally the earth began to cave in, warning the men that the water was breaking through the quicksand which had been encountered.

THE WATER HYACINTH has become such a dangerous aquatic pest in the rivers of Florida that the late Chief of Engineers, Gen. Craighill, recommended an appropriation of $10,000 for the examination of these streams with a view to its extermination. This plant was imported from Venezuela, a few years ago, by the keepers of fashionable resorts and planted in the streams as an attraction on account of its remarkable beauty. But it has spread beyond control and to such an extent that it has become a serious obstruction to navigation. The plant is not known to have any commercial value.

A GARBAGE INVESTIGATING COMMISSION has been appointed at Boston consisting of Messrs. Wm. Jackson, M. Am. Soc. C. E., City Engineer; Benj. F. Wells, Superintendent of Streets, under whose direction garbage is now removed; and S. H. Durgin, M. D., Chairman of the Board of Health.

BRICK STREET PAVEMENT, laid in Indianapolis in 1891, is so badly worn that property owners may be called upon to pay for new pavement before they have finished paying for the old one. Ottawa brick was used, and the pavement is worn down several inches in places, and the surface is uneven and full of ridges. The contractor's guarantee deposit of 20 cts. per yd. has been practically consumed in repairs; but the contractor contends that he did not guarantee against ordinary wear, and he is sueing for the return of his money, as the guarantee on parts of the pavement has expired. Brick pavement laid later in the same city is in much better condition, as the specifications were more strict and the brick used were better.

NEW JERSEY STATE ROAD APPROPRIATIONS amount to $545,000 for the last seven years. But twelve counties complain that they have not received a penny of this state fund, and among these are Bergen and Union counties, which have done much road work by township bonds. These counties now demand some practical state recognition whereby their bonded indebtedness may be lessened and ask for an amendment of the state road law to that effect.

A RAILWAY BOND ISSUE of $50,000,000 in 100-year 3½% gold bonds, has been made by the Lake Shore & Michigan Southern Ry. Co. The purpose of the issue is to refund the entire bonded debt of the company, which now bears 7% interest. The whole issue has been taken by Speyer & Co.

THE FAST RUN made by a special train on the Chicago, Burlington & Quincy R. R., from Chicago to Denver, Feb. 15, was recorded in our issue of Feb. 21, and we give below a table of the running times and distances, as issued by the railway officials:

Mins. between stations.	Miles.	Miles between stations.	Stations.	Arriving time.	Leaving time.	Dead time.	Remarks.
				a. m.	a. m.		
.....	.....	.....	Chicago	.....	10:00	..	
4	1	1	(Commissary) ..	10:04	10:03	4	Supplies.
..	4	3	P. H. Crossing..	.....	.....	1	
37	37	33	Aurora	10:45	10:46	1	Telegram.
.....	.....	.....	C. & N.W. Cr's'g	.....	.....	2	
44	83	46	Mendota	11:30	11:33	3	Water.
				p. m.	p. m.		
83	163	80	Galesburg	12:56	1:00	4	Water.
.....	.....	.....	I. C. Crossing..	.....	.....	2	
48	206	43	Burlington	1:48	1:51	3	Change.
.....	.....	.....	C.,R.I. & P.Crsg	.....	.....	2	
61	261	55	Krum	2:52	2:55	3	Water.
.....	.....	.....	Wabash Crossing	.....	.....	2	
23	281	20	Ottumwa	3:18	3:18	..	
.....	.....	.....	C., M. & St. P. Crossing	.....	.....	2	
24	304	23	Maxon	3:42	3:44	2	Crossing and oiling engine.
33	336	32	Chariton	4:17	4:22	5	Water and oil.
28	363	27	Osceola	4:50	4:52	2	Sent W. U. mess.
32	396	33	Creston	5:24	5:26	2	Change.
34	432	36	Villisca	6:00	6:05	5	Hot truck eng.232
15	447	15	Red Oak	6:20	6:27	7	Change & orders.
.....	.....	.....	O. & St.L.Crss'g	.....	.....	2	
38	483	35	Pac. Junction...	7:05	7:07	2	Change.
.....	.....	.....	M. P. Ry. Crss'g	.....	.....	2	
.....	.....	.....	C.,R.I. & P.Crsg	.....	.....	2	
64	541	59	Lincoln	8:11	8:14	3	Change.
73	610	69	Sutton	9:27	9:30	3	Water.
33	638	28	Hastings	10:03	10:05	2	Change.
75	716	78	Oxford	11:20	11:24	4	Water and oil.
				a. m.	a. m.		
51	770	54	McCook	12:15	12:17	2	Change.
97	860	90	Wray	12:54	12:56	2	Water.
52	913	53	Akron.	1:48	1:50	2	Water.
69	978	65	Roggen	2:59	3:02	3	Water.
.....	.....	.....	U.P. Ry. Cross'g	.....	.....	2	
.....	.....	.....	C.C. Ry. Cross'g	.....	.....	3	
51	1025	47	Denver, U. Dep.	3:53	.....	..	
	1025					86	

			Average,
C., B. & Q...	482 miles	545 mins.	53.06 miles per hour.
B. & M. R....	543 "	588 "	55.41 " " "
	1,025 "	1,133 mins.	54.25 miles per hour.
Less dead time		86 "	58.74 " " "
Actual running time..		1,047 "	

A WATER POWER CANAL at Louisville, Ky., is proposed by Mr. John L. Dunlap, of the Board of Public Works, to utilize the power of the falls. Beargrass Creek would form a part of the canal, and it is proposed to build a large outfall sewer along the line of the canal.

RESERVOIR NO. 5; BOSTON WATER-WORKS.

Reservoir No. 5 of the Boston Water-Works was designed by Mr. Desmond Fitzgerald, M. Am. Soc. C. E., to add 15,000,000 gallons per day to the water supply of the city, and to complete the development of the Sudbury River watershed. Construction was commenced in 1894. When the Metropolitan Water Supply system was planned, it was found that this reservoir would form an important link in the chain of reservoirs and the supply from the new Nashua River reservoir. It was therefore taken over by the Metropolitan Water Board on Jan. 4, 1896, and is now being completed under its direction. The present conduit from this reservoir to the city has a capacity of 100,000,000 gallons daily, and plans have been prepared for a new conduit parallel with this, but this will not be required for some ten years. The new Nashua aqueduct, described in our issues of March 7, 1895, and Feb. 25, 1897, will discharge into the southwest end of the new reservoir by an open channel.

The dam at the lower end of the reservoir was described and illustrated in our issue of April 4, 1895. It is about 2,000 ft. long, with earth embankment construction at either end, and a masonry section 300 ft. long between them, this masonry section forming the overflow. The greatest height of the dam is 75 ft., and the greatest width of the masonry section at the base is 75 ft. The foundations are carried down to bed rock, which is of granite, with seams of mica schist. The rock was partly broken, and had to be excavated to a depth of about 15 ft. at the bed of the stream, making the height at this point 90 ft. above the foundation. The lower part of the down stream side has a curve of 100 ft. radius, while the crest is rounded off with well bonded stones, so that ice will readily pass up and over it. The crest is of cut stone, all the other work being of rubble with rock-faced range work. The gate chamber has three sets of gates, taking water at different levels, and the outlet into the natural channel below the dam is by three 48-in. pipes, the lower ends of these pipes being turned up vertically into a fountain. The contractors for the dam are Moulton & O'Mahoney, of Boston. Each of the embankment sections has a concrete core wall, faced with Portland cement plaster on the upstream side. The upstream part of the bank is a stiff clay almost like brick clay (this material having been readily obtainable in large quantities), while the downstream part of the bank is of gravel. The dam is nearly completed, but work has now been stopped for the season, as no masonry work is carried on during the winter. The crest of the masonry overflow of the dam and its north wing wall are shown in Fig. 1, while Fig. 2 shows the work of plastering the core wall of the embankment.

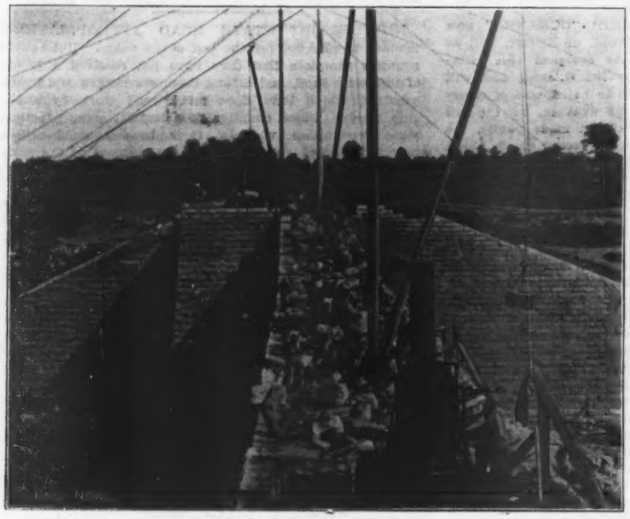


FIG. 1.—NORTH END AND WING WALL OF MASONRY PART OF DAM FOR RESERVOIR No. 5; BOSTON WATER SUPPLY.

FIG. 2.—PLASTERING CORE WALL OF EARTH EMBANKMENT OF DAM.

The area of land under water will be about 1,220 acres, but the city has acquired nearly 2,000 acres of land, so that the land bordering the shores will be all under its control. The outline of the reservoir will be very circuitous, and its perimeter will be about 20 miles. This will all be surrounded by the embankments in shallow portions, and faced with gravel. There will be some islands in the reservoir. New roads had to be built in the town of Southboro, to take the place of those crossing the site of the reservoir. These are excellent gravel roads, better and shorter than the old roads, and therefore costing less for maintenance. There are no railway diversions, but at one point the embankment of the New York, New Haven & Hartford R. R. has been widened for double track and a new arch built, the face of the banks being protected by rip-rapping.

One of the most interesting features of the work on this reservoir is the thorough work of clearing and stripping all the land which will be under water, so as to avoid the possible pollution of water in the storage reservoir by the decay of organic matter, which would be likely to impart an unpleasant taste to the water. All vegetable matter is therefore cleared away and all surface soil removed. This method of treating a storage reservoir has been adopted on the Boston water supply system since 1881. There were complaints against the water in 1880, and the water was drawn off from reservoirs No. 2 and No. 3, and the ground was stripped. No. 4 and 6 were afterwards stripped (before being put in service), but No. 1 has never been stripped.

There will be no shallow flowage, the minimum depth of water being 8 ft. Shallow bays are either excavated to full depth or filled up with the excavated material to a height of 2 or 3 ft. above the high water line, the bank being then sloped to a grade of 3 to 1 and covered with about 2 ft. of gravel. The work consists in general of stripping off all the surface soil, stumps, roots and other organic matter below the contour of the 8-ft. water line. The amount to be removed in stripping reservoir No. 5 is about 4,000,000 cu. yds., and this is being done in 17 sections, as follows: Moulton & O'Mahoney, 4 sections; H. P. Nawn, 3; P. Linehan, 2; F. Saucier, 2; Washburn & Washburn, 2; Phelan & Bush, 1; Malone & Strang, 1; Nevens & Son, 1; Newell & Snowling, 1. Trees are cut down, and the stumps are pulled by stump pullers or blown out by dynamite if very large. The removal of the soil is done by hand digging, the material being hauled away by wagons and teams, or by narrow-gage dump cars. These cars are hauled up from the excavations by cables and hoisting engines, and then taken to the dumping point by horses or locomotives. Most of the engines are the ordinary light contractors' engines, but H. P. Nawn has one of the little geared engines built by the John F. Byers Machine Co., of Ravenna, O., and illustrated and described in our issue of May 21, 1896. The rapidity of the exhausts in this engine sounds as though a very high speed was being maintained, and it is curious to see the train moving so slowly.

The muck and swamps, if shallow, are excavated entirely, right down to the underlying stratum of clean material. Nearly half of the work is done by teams, and the work is progressing at the rate of about 300,000 to 325,000 cu. yds. per month. The loam averages 12 ins. thick on the upland, and 1 ft. to 10 ft. thick on the meadows or bottom land. The muck excavations look almost like the excavations of manure heaps, the stuff giving off so much steam. It is a thick peaty, wet stuff, very light to handle, and when dried out is very light. Excavation in this can be carried on throughout the winter, as the frost penetrates it only to very slight depth. The material is used for filling in around the sides of the reservoir, as already described. The contract prices for this work ranged from 19 to 29 cts., and even 36 cts. per cu. yd. in one case. On the work let to Washburn & Washburn there is a pocket of liquid mud, containing about 1,000,000 cu. yds. The Water Board did not wish pumps to be used in handling this stuff, fearing that it would result in fouling the water, as it is proposed to partly fill the reservoir this winter. A dredge was therefore tried, but did not work well, and eventually the contractors were authorized to use a hydraulic suction dredge, and this will soon be installed. The mud pocket is about 20 ft. deep, but it will be taken out to a depth of only 10 ft., as the proportion of organic matter decreases very rapidly below the surface, so that it will not be reasonable to incur the expense of removing it to a greater depth. At the surface the stuff has about 75% of organic matter, while at a depth of 10 ft. it has only 5%. Two views of the work of stripping and clearing are shown in Figs. 3 and 4.

The laborers employed by the contractors on the digging are mainly Italians, who are found to be the most reliable for steady hard work day after day, although they live mainly on bread. Hungarians, Swedes, Irishmen and negroes are also employed. The laborers get about $1.25 per day. Great care is taken to prevent pollution of the ground. Proper closets and cesspools are built at the several camps, and the men have strict orders to use these. A doctor is employed to supervise the sanitary arrangements and attend to any cases of sickness, but is not required to give his entire time. He has an assistant, however, who is continually going over the work, treating the closets with chloride of lime, and seeing that new cesspools are constructed as required.

The appearance of the surface after the strip-

ping has been done is very singular, being a bare, hard land, plentifully sprinkled with stones and boulders, while a few years ago good farms occupied this site.

It is expected that the reservoir will be partly filled during the present winter, and all work on the dam and reservoir is to be completed by Dec. 1, 1897. The work is under the general supervision of Mr. F. P. Stearns, M. Am. Soc. C. E., Chief Engineer to the Metropolitan Water Board, but is more directly under Mr. Desmond Fitz Gerald, M. Am. Soc. C. E., Engineer of the Sudbury Department. Mr. W. C. Hall is the resident engineer in charge of the dam and reservoir. The work was recently visited by a member of the staff of this journal, who obtained from the gentlemen above named photographs and information made use of in the preparation of this article.

FIG. 3.—STRIPPING AND CLEARING SURFACE FOR RESERVOIR.

FIG. 4.—STRIPPING SURFACE FOR RESERVOIR, SHOWING PART OF THE CLEARED SURFACE.

SOME OPEN QUESTIONS CONCERNING STRUCTURAL STEEL.

In the January number of the "Proceedings of the Engineers' Club" of Philadelphia is to be found an exceedingly interesting topical discussion of certain open questions concerning structural steel. We present several of these practically in full, beginning with the following paper by Mr. H. H. Campbell, Superintendent of the Pennsylvania Steel Co.:

1. General Suggestions on Specifications for Structural Steel.—The greatest question in the manufacture of steel is the amount of phosphorus that is allowable. We say that the influence of phosphorus is mysterious and that its action is treacherous, by which we mean that the laws governing its action have not been formulated. Until they have been, the only safe way is to limit the allowable content; some engineers give 0.10% as a maximum (which will do very well for ordinary material); some, .08, some, .06, some, .04. Whenever there is a low limit to the phosphorus, you will find that the manufacturer will make that steel by the basic process. Some of you have a prejudice against the basic open-hearth, and therefore you will perhaps write in your specifications that the steel shall be made by the acid open-hearth process. You receive two bids, one high, the other low. You take the low, of course. Three months afterward you find that you are getting basic open-hearth. You object, but the manufacturer answers that the clause did not mean anything. What are you going to do? He will not make the steel by the acid process perhaps, because he has no acid furnaces. You cannot sue him for breach of contract, because you cannot prove it is inferior material; and so you swallow the basic steel. The slightest consideration will show that you have not dealt fairly with the manufacturer who bid a higher price on low-phosphorus acid steel. This matter is an important question, and it is very desirable that engineers place nothing in the specifications they do not intend to carry out.

It is proposed by some engineers that phosphorus be guarded against by impact tests. I claim that these are entirely unnecessary in the majority of cases. They may do in axles; but in angles and beams and so on, it merely means the destruction of a great deal of good material and a great deal of delay, because you cannot make such tests until the shapes are all rolled. Moreover, they are of little value. You can find out whether the material is good by analyzing it. Unless the steel is burned you will usually have no trouble with the impact test, and you cannot discover over-heating by making one such test; one end of the bar may be burned and the other end be all right, or one small bar may be burned and all the other bars be in good condition. You must trust in great measure to the manufacturer. Moreover, if the bar is burned you can discover the fact by the tensile test just as well as by an impact test; and as for phosphorus, analyze for it, don't make an impact test.

There is a tendency in many specifications to limit the amount of sulphur. There are some people who disagree with me, but I do not think that sulphur ought to be specified on anything except rivets and eye-bars, and, of course, on flange steel for boilers. On other work I do not see what the engineer has to do with sulphur. You never heat an angle outside of the shops. A railroad bridge is not supposed to go through a conflagration and then be bent up and cracked. Rivets have to be heated after they leave the steel works and, therefore, it is necessary to guard against red-shortness; but if the manufacturer can work his steel into angles and beams or shapes, and can get them into a perfect section, I do not see what right the engineer has to throw out a hundred tons of bars, angles or beams, just because they run .001 or .01% above an arbitrary limit.

You write your specifications say 60,000 to 68,000, when, by the way, you should always give 10,000 lbs. leeway and say 60,000 to 70,000; and then you say 38,000 elastic limit; 25% elongation; 50% contraction of area. This is all wrong. If 38,000 lbs. elastic limit is right for the 60,000 steel, it is wrong for the 68,000; and if it is right for the 68,000, it is impossible for the 60,000. It is simply a law of nature that the elastic limit is proportional to the ultimate strength, and you cannot get away from it. You ought to make the elastic limit a percentage of the ultimate strength. The elongation will depend somewhat on the section; the contraction of area depends still more upon the shape and size of the piece. In a 3 × 3-in. angle you may get 50 to 60% contraction of area, while a 6 × 6-in. angle rolled from the same ingot will give only 40 to 45% contraction of area. It is the very same steel exactly, made out of the very same bloom, if you like, and yet it will not give the contraction of area. It is not the fault of the steel, it is the fault of the section of the piece. Take the same heat, the same ingot, and roll one bloom into a 6 × 8-in. angle an inch thick, and one bloom into a 3 × 3-in. angle one-quarter inch thick, and the heavier bar will be two, three or four thousand pounds lower in ultimate stength. The two are exactly the same steel and yet an engineer will often accept one and reject the other. I have always fought for a sliding scale for all shapes. A variaion in the section produces a variation in the ultimate strength, the elastic limit, the elongation, and particularly in the contraction of area; and specifications ought to take that into account, particularly on forgings. Take a specification such as I mentioned; if it is a proper specification for angle and eye-bars, how can it apply to forgings? A piece cut from a forging will not give as good an elongation nor contraction of area. We had one specification calling for a piece cut out of the central core of a pin, and requiring that this piece should show as much contraction of area as a 3 × 3-in. angle. This is absurd.

We have a specification on our books now, requiring that, in the annealed eye-bar, the tensile strength shall not vary from the unannealed bar more than a few thousand pounds. The engineer did not know that he was insisting on bad material. The purer the steel, the more carbon it must have; and the more carbon it has, the more sensitive it will be to annealing or other heat treatment; and, therefore, the purer the material, the more it will fall off in the annealing, other things being equal. Of course, if a bar were finished too cold, it would be influenced by annealing more than it ought to be, but the danger from this source may be neglected, since the annealing will remove all injury that a bar will receive from cold rolling in any ordinary rolling mill.

Another point is the amount of segregation that is allowable. This segregation is an ever-present factor, sometimes greater than it ought to be; we don't like to have it at all, but it is and always will be present to some extent. You specify that your steel shall be .08 phosphorus, but you do not say how that test is to be taken; but we suppose, and there is generally no misunderstanding, that the test is to be taken in the usual way, according to the general practice of the country; but once in a while we run against an inspector who wants to take it another way. That is wrong. When you buy a roast of meat, you buy bone and meat. You don't expect to get meat alone and take off the weight of the bone; so when you get a bar of steel, you can find a part that is segregated. We want these facts to be known. As soon as everybody knows just how bad it is and just how good it is, so much the better. The top of the ingot should be cut off; but all down through the center you will find a little segregation, and I claim there ought to be an allowance of 25 to 33% allowed for the maximum content of phosphorus or sulphur. Mr. Cunningham allows that in his specifications. He is the only expert inspector who has come out publicly in favor of such an arrangement; and he knows that this is the proper thing to do while insisting on good material. If you want .08 in the most segregated portion, then specify .06 for the average. I believe that inspectors in general think that manufacturers ought to have a little more leeway. These inspectors understand their business; they know just about what is wanted; what the engineer wants; what the steel-maker can do. They understand the variations caused by variations in section and shape, but they have no power to exercise their own judgment at all. The engineer gives them a certain schedule and expects them to carry it out. He might just as well hire a clerk for a dollar a day if the sole requirement is that he shall carry out a complete set of specifications. With a little more leeway given to common sense and knowledge, the engineer will get just as good material.

Mr. Albert Ladd Colby contributed a paper to the same discussion treating of the chemical components of steel, but contending that failure is more often due to faulty mechanical treatment than to the presence of rare elements in the steel itself. Mr. Frederick H. Lewis advocated "The Use of Higher Carbon Steel in Structural Work," as follows:

3. The Use of Higher Carbon Steel in Structural Work.—The close of the present year marks the end of a cycle of revolutions in which steel has replaced iron in construction, with all the concurrent changes in metallurgy which this implies. In the transition period we have run the gamut from hard steel to medium, and from medium to soft, and it is upon the latter that opinion has finally agreed. Though the discussion has been long the decision seems to be nearly unanimous.

But the world still moves and metallurgy is not yet a completed and perfect science. It continues to present new results and new facts for our consideration. And it happens that just now metallurgists are able to show remarkable results in the production of the medium carbon steels. And so it is that I, who five years ago urged on this floor the general use of soft steel, which has since come to pass, am here to-night to suggest quite a different practice.

Ten years ago steel manufacturing in this country (excluding tool steel) consisted of rail industry in Bessemer steel, a small boiler plate industry in open-hearth steel, and a tire and forging industry also small, and also using open-hearth steel. The Bessemer interests greatly predominated both in capital and in plant. The open-hearth process was at a disadvantage in cost of production, and hence for the most part limited its product to a higher grade of steel and a few special lines. The proper handling and working of steel in general mill practice was little understood and the whole development of the industry outside of a few lines indicated above, was still to take place. Hardly one in a score of difficulties which are now understood and in some sense provided for, was then recognized.

It was under these conditions that structural work in steel began in this country and a number of great bridges were built under these serious limitations. The Eads bridge at St. Louis, the Blair and Bismarck bridges over the Missouri, the Brooklyn bridge, the Niagara cantilever bridge and others were built under such conditions, and nearly all of them were built of hard steel of a tensile strength of 80,000 lbs. or over. Now none of these bridges were in any sense unsatisfactory as structures, but there was considerable trouble, and quite a few minor failures in shop work, particularly with Bessemer steel. It was under these circumstances that opinion began to favor softer metal.

To-day the steel industry in this country is on a totally different basis. The great Bessemer process, which has done so much for civilization and to which America owes more for its great development than to any other agency except the steam engine, is a greatly diminished factor. After an expansion in which Bessemer steel entered into almost every type of constructional work, its field has been narrowed with the growth of the open hearth industry more and more closely to its original specialty of rail manufacture; and even in rails specifications are being adopted which present great difficulties to the Bessemer process.

Ten years of practical manufacture, experiments, tests, analyses and research, almost to weariness, have established steel making both as a science and as an art. The development of the basic process producing normally a soft steel of great purity and furnishing incidentally an increased stock of pure raw material, has made it possible to produce cheaply steels of high quality and of almost any grade. Lastly, we have great plants at Bethlehem, Midvale, and at Homestead, achieving remarkable success in making and manipulating great masses of fine steel.

Now it is to higher carbon steels of greater purity, and to these newer processes of manufacture, that metallurgists are asking the attention of civil engineers. Indeed, experienced steel makers have been practically a unit for a number of years in considering a pure steel with a carbon percentage from 30% to 60% as the finest product of the Siemens-Martin furnace and the most trustworthy material for construction purposes. They have not been, therefore, in sympathy with the recent practice in structural work. It will be remembered, for instance, that Mr. Wm. Metcalf, of Pittsburg, whose standing as a metallurgist is recognized at home and abroad, has declared that soft Bessemer steel is rotten steel. And Mr. John Fritz, summing up 60 years of experience in iron and steel manufacture, says in his recent address before the Mechanical Engineers: "To those persons who are using steel low in carbon for various purposes, I would urge the use of a higher grade of steel, knowing it would answer their purpose better." These views fairly reflect a widespread opinion. Steel of this character as now made in the acid open-hearth furnace, is tough, sound, as homogeneous as steel can be made, and a wholly different material from the low grade product of the Bessemer converter recarburized in the ladle. It is indeed the grade of steel which engineers had in view in their early practice in steel bridge building, and there is very little doubt in my mind that if they could have obtained then such material as can be had now, the development of our practice in structural work would have been on quite different lines.

Why are we using soft steel bridges to-day? There are two reasons: first, because the supply of such material is abundant and cheap, and second, because of its flexibility it is easily manipulated and worked in manufacture in the shop. These are the real reasons why we are using that material and are the grounds on which I took occasion to urge its use before the club some time ago. But ask engineers who are not in touch with steel making and metal working, why it is they prefer very soft steel, and nine times out of ten they will answer that they think it is just the stuff to stand impact because there is no danger of its snapping. Snapping is the word which is used, leaving one under the impression that it is a peculiarity of all other steel to snap. This opinion is erroneous on both counts. Soft steel is not the best material to resist impact, and if impact were great enough it would certainly snap. For when it comes to impact it is useless to pretend, for instance, that the conditions in a bridge stringer are anything like as severe as they are in rails with stresses which alternate under every wheel as it passes from tie to tie and subject to the direct shock of the loads; or to contend that the stresses in eye-bars are as severe as in engine-connecting rods in rapid motion and subjected to stresses alternating eight or ten times a second; or that any part of a bridge is subject to the shocks received by tires and axles. Yet for these uses, soft steel will not do. It is a failure. What is it which enables high carbon steel of very ordinary quality to do good service for years in rails and tires when soft steel fails? The reason is simply this, that the high initial rigidity of the material enables it to stand shock without deformation. Rails are enabled to perform the service which they do to-day because the elastic limit of the metal generally exceeds 50,000 lbs. per square inch; and for no other reason. I know of no better way of enforcing this point than by quoting a recent writing of Mr. James E. Howard, who for years has been in charge of the Government Testing Laboratory at the Watertown Arsenal, Mass., and whose experience in testing metals is quite unequaled in this country, and probably by any one now living. Mr. Howard says:

It has been shown that rails originally very tough but of low elastic limit and tensile strength have lost materially in strength and become brittle as the result of cold flow under wheel pressure. In other words, by reason of a low elastic limit the stresses imposed, caused readily a development of the elongation of the metal, and after that had taken place, fracture was effected, with reduced loading and without the display of appreciable permanent deflection. With rotating shafts it is shown to be unnecessary to overstrain the material beyond the limits barely showing a permanent set when observed with a micrometer, in order to eventually cause fracture. The mere possession of great toughness in the original metal does not signify that the metal will display any toughness before rupture; but, on the other hand, a succession of loads, no one of which causes distortion to the unaided senses, will ultimately end in rupture no less brittle than that of the hard steels. In steel of maximum tensile properties there is so little mobility of the parts that a lack of homogeneity, internal strains, or a concentrated stress, may cause sudden fracture. * * * On the other hand, we are quite certain that the very soft grade of metal will be easily overstrained, and under repeated alternate stresses ultimately fail under precisely the same appearance of brittleness that the hardest metals fail; i. e., in neither case will there be any display of toughness. Now the intermediate grades of steel will also do the same thing, but the advantage they have is this: they will endure a larger number of repetitions of stresses, and stresses of higher magnitudes than the softer grades.

Nothing could be clearer than this; nothing more damaging to the overestimate commonly placed on the value of softness or ductility. Fracture is due to overstrain and in metal of good quality can be caused by nothing else. This was the demonstration of Bauschinger's celebrated experiments since confirmed by Mr. Howard's own work at Watertown. It is singular that this great fact which metallurgists and mechanical engineers have not failed to note, has so generally escaped the attention of civil engineers.

It is a matter of interest to note also that these remarks of Mr. Howard's are called forth by the report of an investigation into the quality of steel required in the very latest type of structural material, the cold-drawn seamless tubing for bicycle frames. Lieutenant Eames of the Pope Tube Co., of Hartford, Conn., as the result of careful investigation and many experiments declares that (with a possible exception of nickel steel) a pure steel containing 0.50% carbon is the only material which can be fully relied upon to meet this service.

Now, it must be admitted that a bicycle frame weighing only 7 or 8 lbs., which is not only capable of carrying a man of 200 lbs. or more, but will remain rigid under his utmost muscular efforts and withstand the shocks of road riding, is an engineering evolution as notable in its way as a truss bridge. Hence these conclusions of Lieutenant Eames are interesting, especially as they have called forth the cordial endorsement, first of Mr. Howard, and later of Mr. John Fritz, the venerable engineer and superintendent of the great plant at Bethlehem.

So far then as impact and snapping are concerned, it must be admitted that our fears are not well founded; are, indeed, unscientific, and the fact remains as stated above that we are using soft steel chiefly because of the advantages it offers in manufacture. This consideration will undoubtedly continue to give soft steel the chief place for efficiency and economy in structural work. But when it comes to requiring soft steels to be reamed or drilled in the solid, to the use of soft steel in bridge trusses of large span, to its use in pins, rollers and bed plates, I thing it is time to raise a question as I have done to-night, and ask if economy, good shop practice and sound engineering would not be better served by the use of higher carbon steel.

Mr. James Christie, M. Am. Soc. C. E., briefly reviewed the influence and effect of dynamic stresses on material and structures. He based his remarks on the following statements: The forces acting on materials in use are to a large extent of a dynamic character; and when iron or steel is destroyed by a stress of this kind, they usually yield progressively. There is a marked difference in the comparative endurance of different grades of metals, and the advantage does not remain with the very ductile metal of low tensile strength; finally, the usual method of testing by direct tension does not furnish sufficient indication of the capacity for long endurance to dynamic stresses. Mr. Colby gave the results of the experience of the Bethlehem Iron Co., in using high carbon steels for forgings for shafting, crankpins, hammer-rods, etc. These examples all showed most excellent physical results.

Mr. Gus. C. Henning exhibited and described a mirror apparatus for minute measurements of change of length, and also a pocket recorder for stress-strain diagrams. Mr. P. Kreuzpointner, who is in charge of the testing of metals for the Pennsylvania Railroad Co., at the Altoona shops, addressed the club as a metallurgist, rather than as an engineer. In regard to the objections made by Mr. Campbell to the impact tests for bridge steel the speaker related the following personal experience: He recently received for test an engine truck axle which showed a fine crack all around the periphery of the journal. To this axle a load of 100,000 lbs. was applied in the testing machine, without further visible result than the indentation made by the knife-edge of the gage. But when this axle was placed on supports 5 ft. apart, one blow of a 3-ton steam hammer, falling 6 ins., made the axle break through the crack like glass. Mr. Kreuzpointner believed that, other things being equal, middling hard steel gives much better and safer service than soft steed where the structure is subject to shocks, vibrations and intermittent strains of all kinds. He claims that it is the degree of elasticity which determines the life and safety of structural steel, and middling hard steel, such as described in Mr. Lewis' paper, has a comparatively high elastic limit with sufficient ductility to act as a buffer to neutralize the shocks and stresses imposed upon the metal. Such steel is not so easily fatigued and, consequently, not so liable to break in detail.

Mr. Kreuzpointner agreed with Mr. Christie as to the importance of improving upon present methods of ascertaining the physical qualities and properties of steel. He objected to the crude method of determining the elastic limit by the "drop of the beam," and the contraction of the area. The last is nothing more than the last gasp, as it were, in the dead struggle of the material, a period in the life of a structure which the engineer never contemplates seeing. He illustrated his remarks by the result of his own experiences; and quoted Bauschinger as showing that the difference in the elastic limit was 5 to 20%, as ascertained by the drop of the beam and as measured by the Bauschinger mirror apparatus. He also called attention to the fact that the elastic reaction, taking place in iron or steel after it has been relieved from the straining stress, may last for hours, days or weeks. This elastic reaction is not determined by the test referred to, and is an unknown quantity; for the drop of the beam simply indicates a highly disturbed stage in the metal, dangerously near the limit of safety in some cases. If the structure is subjected to a load thus determined, the elastic reaction may continue after the load creating stress is removed; and long before the agitation in the metal has ceased and the metal assumes its normal stage it may be strained again; and if there is a constant repetition of this process, the metal never recovers fully, but is weakened before its time. If this structure breaks down suddenly, or in detail, but unexpectedly, we are apt to hear talk of a mysterious failure.

LOCATING OBSTRUCTIONS IN UNDERGROUND PNEUMATIC TUBES IN PHILADELPHIA.

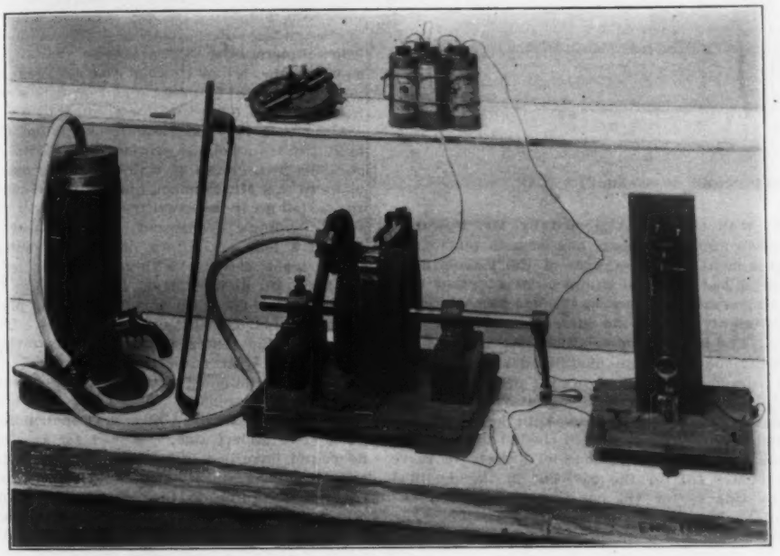
By B. C. Batcheller.*

Philadelphia has a pneumatic tube system, the first in the United States, connecting the general post office and a substation in the banking district of the city. The length of the system is a little over half a mile, and two cast-iron pipes, 6⅛ ins. inside diameter, form the conduits through which the mail is sent at a speed of 50 ft. per second. These tubes are bored smooth, and through them are forced, by compressed air, light steel cylinders, or carriers. The system had been in uninterrupted operation for four years when the first accident occurred, a few days ago, as the supposed result of some settlement in the ground containing the pipes. One of the broken ends of the tube dropped down and obstructed the passage of a carrier, and before the accident was discovered a second carrier was sent after the first. The problem presented was to locate the position of the break in the pipe system, buried 4 to 5 ft. below the asphalt pavement on Chestnut St.

An attempt was made to force the carriers through the tube by an increased pressure of air applied, first in the direction in which they were despatched and afterwards in the reverse direc-

*Chief Engineer, Pneumatic Transit Co., 906 Walnut St., Philadelphia, Pa.

tion, but all such attempts failed to remove them. Another attempt was made to locate the break in the tube by a careful examination of the pavement of the street above the tubes, with a hope that an escape of air could be detected. At one point a man was sent into the sewer that lay parallel and near the tubes, for the same purpose, but no escape of air could be discovered. It was then decided to try and locate the carriers by firing a pistol into the end of the tube and noting the time that elapsed between the discharge of the pistol and the sound of the echo reflected back from the obstructing carrier. Knowing the velocity of sound and the time that it takes it to travel along the tube to the carrier and back again, a very simple computation would give the exact location of the carrier from which the sound was reflected. The problem that confronted us was to measure with precision this short period of time. Since sound travels with a velocity of about 1,100 ft. per second, it became necessary to measure the time accurately to a thousandth of a second. To do this a chronograph was hastily constructed, together with a clock to indicate seconds and mechanism for recording upon the chronograph cylinder the sound waves of the pistol discharge. The entire apparatus is shown in the accompanying cut.



APPARATUS USED IN LOCATING OBSTRUCTIONS IN PNEUMATIC TUBES, PHILADELPHIA, PA.

The chronograph consists of a cylinder 5 ins. long and 10 ins. in diameter, mounted upon a horizontal shaft having a screw upon one end to give it a longitudinal motion, and a crank upon the other end by which the shaft and cylinder are revolved. The shaft is supported by two bearings that are mounted upon the base of the instrument. The polished surface of the cylinder is prepared for receiving its record by depositing upon it a thin coating of lamp black, or smoke, by burning resin under the cylinder as it is slowly revolved.

In order to measure these very short intervals of time a tuning fork was used, having a known rate of 512 single vibrations per second, giving the note C of the musical scale. It is mounted in a horizontal position just above the cylinder, being supported from the base of the instrument by a standard with adjusting screws. A short piece of horse hair is cemented to the end of one of the prongs of the fork and so adjusted as to just touch the surface of the cylinder. When the fork is vibrated by bowing and the cylinder is revolved, a wave line is traced upon the smoked surface of the cylinder, each single wave measuring $\frac{1}{51}$ of a second. Quarter waves can be easily estimated.

In front of the cylinder is a standard supporting an electro-magnet connected by wires with a battery and a clock. The armature of the magnet carries a light arm and on the end of this arm is a stylus bearing lightly upon the cylinder. When the electric circuit is closed by the clock the attraction of the armature to the electro-magnet gives the stylus a slight lateral movement which appears as a hitch in the smooth line drawn by the stylus when the circuit is broken. These hitches appear at every beat of the pendulum and measure half seconds when the clock is properly regulated and other adjustments are made. The electric circuit is closed at the clock by the end of the pendulum swinging through a globule of mercury supported beneath it, which occurs at the middle of each beat.

We have thus two independent means of measuring time, the tuning fork and the clock. If only short intervals of time were to be measured we might do away with the latter, but when the period exceeds three or four seconds the work of counting thousands of small waves becomes very laborious, and the clock is of great assistance; besides, one is a check upon the other and errors are less likely to occur. Five cells of dry battery were used in the clock circuit.

At first it was intended to have the pistol discharge and the reflected sound recorded on the chronograph cylinder by the same stylus that marks the beats of the pendulum. To this end a diaphragm was stretched across the end of the tube near the point where the pistol was discharged. A piece of platinum was cemented to the center of the diaphragm and just out of contact with the point of a screw, so adjusted that the slightest vibration of the diaphragm would cause the platinum to touch the screw point and close the electric circuit, including the electro-magnet that moves the stylus by forming a shunt circuit around the clock. This method was found to have two objections. First, the diaphragm had to be made stiff enough to withstand the direct discharge of the pistol and then it would not vibrate by the reflected sound waves or echo. Second, the circuit was frequently closed about the same time by the diaphragm and the clock, and then it was difficult to determine the exact instant when the pistol was discharged. These difficulties were all overcome by using a separate stylus, moved mechanically by the sound waves to record the event of the pistol discharge and return of the sound.

In front of the cylinder and close to the electro-magnet a circular concave metal plate about 4 ins. in diameter is supported by an iron standard from the base. A thin rubber diaphragm is stretched over the concave face of the plate forming a small chamber between the diaphragm and the plate. Direct communication is made between this chamber and the end of the pneumatic tube by a rubber tube ⅝-in. inside diameter. There is a central opening in the plate for the rubber tube connection, so that sound waves coming through the rubber tube impinge directly upon the rubber diaphragm, which can be made sensitive to very weak sounds. The vibrations of the diaphragm are recorded on the cylinder by a light aluminum arm, with a stylus upon the end of it. The arm is pivoted at one end and bears against the center of the diaphragm, being held there by a light spring. A metal guard plate is secured just in front of the diaphragm to prevent too great distention and injury. As a further protection against too great vibration of the diaphragm from the direct discharge of the pistol, a cock is placed in the rubber tube which can be nearly closed before firing the pistol and opened immediately afterwards, but before the echo returns.

Referring again to the illustration of the apparatus, on the left may be seen a vertical cylinder closed at the top, having a flange at the bottom and a pistol thrust into a hole at the side. This cylinder is a piece of common 6-in. steam pipe which is bolted to the end of the pneumatic tube, forming a short extension, with the end of it closed by a wooden plug with a small opening in the center for the rubber tube connection. The rubber tube terminates upon the interior with a tin funnel to gather in the sound waves.

The accident occurred on the evening of Jan. 4, and the writer was informed of it about 11 o'clock on the following day. Orders were then given for the construction of the instruments and the first rough measurements were made two days later that indicated the location of one of the carriers 100 ft. east of Seventh St. Workmen were ordered to dig up the street at this point and the tube was found broken 20 ft. farther east; but the carrier lay in the tube, not at the break, but almost exactly where the men were told to begin digging. The broken length of tube was taken out and the open end closed with a wooden plug. Five experiments were now made to determine the distance of this plug from the station where the chronograph was located, and the results were as follows:

	Time.
First experiment	2.791 seconds.
Second "	2.794 "
Third "	2.793 "
Fourth "	2.793 "
Fifth "	2.794 "
Mean	2.793 "

A thermometer was placed in the ground beside the pipe and the temperature found to be 39° F. It was assumed that this was the temperature of the air in the tube. The velocity of sound at 32° F. was assumed to be 1,093 ft. per second and the increase of velocity for each degree Fahrenheit to be 1.12 ft.; this gives at 39° the velocity of 1,101 ft. per second. In 2.793 seconds the sound would travel 3,075 ft., which locates the plug at 1,537 ft. from the instrument. Measurements on the City plans gave exactly the same distance.

After the broken section of tube was replaced, experiments were made to locate the second carrier, which was known to be in the tube. The distance obtained, as the mean of three experiments, was 2,651 ft.

There is a bend in the tube where it turns to enter the main post office at 2,671 ft., and it was suspected that the carrier was lodged in that bend. Our suspicions proved to be well founded, for when the street was dug up at this point the carrier was found and soon removed. In this case the carrier was located within 20 ft. and at a distance of half a mile. At the time of this experiment the effect of the character of the reflecting surface upon the velocity of sound was not known and this accounts for the error of 20 ft. in the location. This effect of the reflecting surface is one of several interesting facts developed by these experiments.

When the broken end of the tube was closed by a wooden plug having a flat end for a reflecting surface, presenting the end of the grain of the wood, a sharp echo was obtained that made a sharp short record upon the chronograph, and the front of the forward wave of the echo showed compression of the air. When the sound was reflected from the rear end of the carrier, a somewhat irregular metal surface, the echo was less sharp, the waves on the chronograph cylinder were long drawn out, making it rather difficult to determine just where they began, and the front of the first wave showed a rarefaction of the air.

Furthermore, the time was shorter, giving a greater velocity when the sound was reflected from the rear end of the metal carrier than when reflected from the wooden plug. By determining the velocity of sound from experiments under definite conditions of temperature and character of the reflecting surface, we are able to locate obstructions under similar conditions with great precision. Even when these conditions are not exactly known the errors are not large and the method becomes of great value. The measurements can be easily and quickly made when the apparatus is at hand.

The method originated, I believe, with M. Ch. Boutemps of Paris and was successfully used by him for locating obstructions in the small pneumatic tubes of that city. It is impossible to say what the limits of the method are so far as distance is concerned, but experiments of Regnault show that the report of a pistol is no longer heard at a distance of

1,159 meters in a tube of 0.018 m. diameter.
3,810 meters in a tube of 0.300 m. "
9,540 meters in a tube of 1.100 m. "

But the same sound waves will vibrate a sensitive diaphragm at distances of 4,156, 11,430, and 19,851 meters respectively.

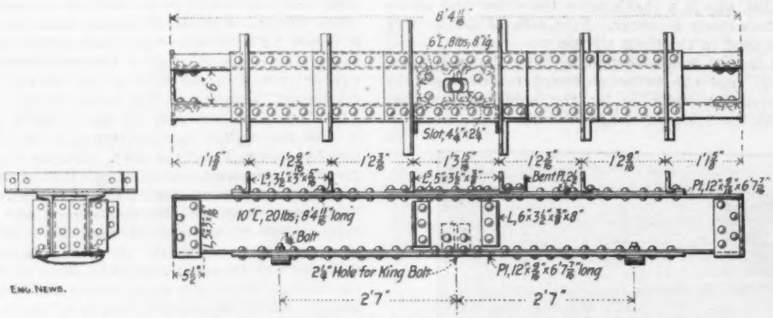


FIG. 7.—DETAILS OF BOLSTER, FOR IMPROVED PENNOCK 80,000-LB. FLAT CAR.

RECENT DESIGNS FOR STEEL CARS, UNIVERSAL CONSTRUCTION CO., CHICAGO, ILL.

(With full-page engraving.)

The designs for steel cars shown on our inset sheet this week are deserving of particular attention, in view of the recent investigations carried out by the Master Car Builders' Association and various railway companies and car manufacturers regarding the possibilities of steel as a substitute for wood in car frames. In Engineering News of July 2, 1896, the report of the special committee of the Master Car Builders' Association on metal underframing for cars was printed in full. This report is much the best exposition of the fundamental principles of the question considered which has yet been made, and it is of particular interest to study the work of car manufacturers in the light of its statements. The two cars illustrated are the latest work of the Universal Construction Co., of Chicago, Ill., which, as our readers doubtless know, has taken a leading position among manufacturers in promoting the adoption of steel cars.

About a year ago the Universal Construction Co. secured control of the patents of Mr. Willard Pennock, of Minerva, O., and also the Harvey patents for steel cars covering special designs of steel car construction, and in May, 1896, the company engaged the services of Mr. D. W. Bowman, as Chief Engineer of its car department. After building one or two cars after the original designs of Mr. Pennock, Mr. Bowman began to study to obtain improvement and finally produced the modified Pennock design shown by Figs. 1 to 7 inclusive. Further developments followed, but at present attention will be given to the improved Pennock car.

The essential peculiarity of the Pennock car is the employment of cold rolled steel channels for the floor. These channels are riveted together flange to flange and run lengthwise of the car. As will be seen from the drawings this construction makes the floor a structural part of the car frame, and has the disadvantage that a merely local injury necessitates for its repair a material disturbance of the whole structure. The longitudinal channels are held together at the sides and ends of the car by plate girders, as clearly shown by the drawings, and also at intermediate points by the bolsters and transverse needle-beam stiffeners. In the original Pennock design the bolsters were made up of malleable iron castings set between and bolted to the channel flanges and held together and supported by truss rods. This construction was shown in detail in our issue of July 2, 1896. Several cars were made according to the original Pennock designs, including flats, gondolas and hopper cars, and two of these were exhibited at the convention of the Master Car Builders' Association, at Saratoga, N. Y., in June, 1896. Later, a car of modified design was made with changes suggested by Mr. Bowman, as above noted. This car has been in service for several months in the yards of the Illinois Steel Co., and has given so complete satisfaction that the Universal Construction Co. has recently completed eight more of the same design for service there. The bolster construction is the part most radically changed in the modified design, as will be seen from Fig. 7, which shows the present box girder bolster. In the original design also two T-beams, or more exactly two I-beams, split longitudinally so as to form a T-beam were riveted flange down to the two center floor channel flanges to serve as a center sill for the car, but in the modified design this center sill construction was abandoned.

The buffing and collision shocks, it will be seen, are conveyed to the bolsters and thence, by their attachments to the floor channel flanges and side girders, to the longitudinal members of the car. A very material proportion of the buffing shock is thus resisted by the side girders, the intermediate girders—i. e., the floor channel flanges—taking a smaller part owing to the eccentric load which the thrust against the bolster brings upon them. The warrant for abandoning the center sill evidently lies in the capacity of the side girders to resist shock and the capacity of the intermediate bolster connections to prevent distortion of the bolster by flexure, and doubtless these qualifications may be open to dispute. In the committee report of the Master Car Builders' Association it will be remembered that one of the requirements especially recommended was a strong center sill construction to act as a column to resist buffing and collision shocks. Indeed, in this report the desirability of making the center sill the very backbone of the car and other longitudinal members subordinate was urged.

Turning to other features of the construction indicated by the drawings, it needs to be noted that the floor channels are rolled cold from soft, open-hearth steel plates, a special train of rolls being used through which the plate has to be passed but once. All the other members are made of ordinary commercial Bessemer or open-hearth steel as may be desired. The side girders, which have already been stated to be the main longitudinal members of the car, are designed to carry an 80,000-lb. load, with a unit tensile strain of 12,500 lbs., giving a factor of safety of about five. Altogether the weight of the body of the car is 13,000 lbs., and the trucks weigh 12,600 lbs., making a total tare weight of 25,600 lbs. The trucks were made by the Haskell & Barker Co., of Michigan City, Ind., and have the M. C. B. standard 4¼ × 8-in. journals. The car is also equipped with Westinghouse air brakes and Tower malleable iron couplers. Fig. 8 is a bottom view of the car showing the brake rigging and the general appearance of the framing, and Fig. 9 is a view of the completed car ready for shipment.

Altogether the Universal Construction Co. has built 15 cars after the original and modified Pennock designs, eleven of which are flat cars. Previous to this Mr. Pennock himself had constructed and tested a car in actual traffic and with various static loadings. This car, under these tests, carried a load of 70 tons of pig iron piled between truck centers, with a deflection of only 1⅛ ins. In another test the load of 159,200 lbs. was divided, about 45,000 lbs. being placed at each end and 69,200 lbs. at the center. The deflection at the center was ⅝-in. and at the ends 3-16-in. and ¼-in. respectively.

Following the construction of the Pennock cars a design was prepared by Mr. D. W. Bowman, Chief Engineer of the Universal Construction Co., for a steel underframe, designed for any kind of floor and covering. The idea was of course to provide underframes which could be mounted and covered according to the desires of railways or other car owners. Figs. 10 to 16, inclusive, show the details of one of these frames designed for a stock car of 40,000 lbs. capacity. It will be noted that this frame has a continuous center sill composed of two channels braced together and to the side sills, as shown by Fig. 16. The draft rigging is attached directly to the center sill, which thus receives directly all buffing shocks and transmits them to the other framing. It will also be noted that the bolsters are made continuous by means of the splice plates extending over the center casting. All other details are sufficiently explained by the drawings. In designing this frame Mr. Bowman worked on the principles governing the

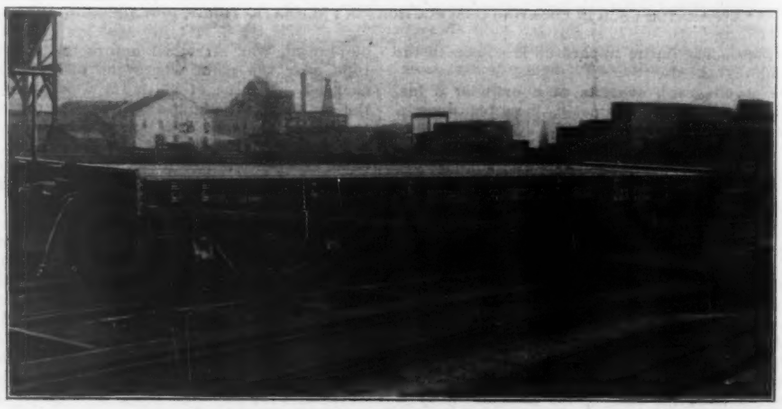


FIG. 8.—IMPROVED PENNOCK 80,000-LB. FLAT CAR.

best structural design in metal, and distributed his metal in the manner which seemed to him to satisfy best the various strains which would be brought to act on the frame. In conclusion it may be mentioned that a comparative study of the cars

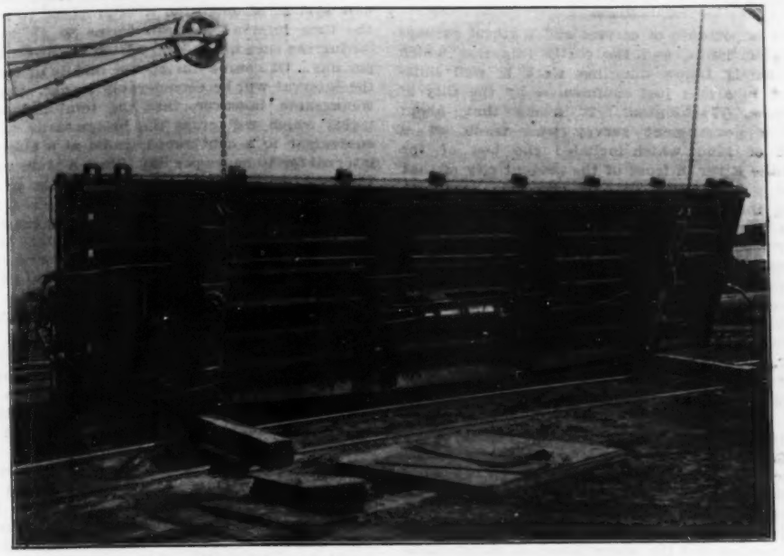


FIG. 9.—BOTTOM VIEW OF IMPROVED PENNOCK STEEL FLAT CAR.

illustrated here with those presented by the committee of the Master Car Builders' Association in its report in our issue of July 2, 1896, above referred to, will prove interesting.

THE REPORT OF THE STEAM USERS' ASSOCIATION.

The Steam Users' Association, which was organized about a year ago by Mr. Edward Atkinson, of Boston, has issued a report of its work for the past year and an appeal to its subscribers for funds to continue the work for another year. Mr. Atkinson states that it will not be found expedient to attempt at present to form a permanent association, nor will it probably become expedient to organize under a charter for boiler insurance. The following is the outline of work which is proposed to be undertaken:

1. A report on the efficiency of heating surface in different types of boilers.
2. Experiments in the flow of air through brick walls.
3. Experiments on determination of moisture in coal.
4. Report on tests of weathering of coal.
5. Gas analyses and temperature measurements on down-draft furnaces, mechanical stokers, etc., to determine their real value as compared with ordinary methods.
6. Expert work on individual plants of members.
7. Investigation of the scale forming and corrosive powers of boiler feed waters.
8. Tests on reliability of water meters for measuring boiler-feed water.
9. Analysis of cost of engine room labor.

Owners and users of boilers are asked to contribute $2 or $3 for each boiler owned to a fund to be used in prosecuting these researches.

Circular No. 7, included in the pamphlet, contains a report on mechanical stokers. An attempt was made by a circular letter to find what the members who were using stokers thought of them. Of sixteen replies to the question whether the stokers saved coal over hand-firing, one reply showed a loss in economy, five no saving, six a saving, and five could not tell. Replies to the question whether the stokers saved labor were: One increased labor, three no saving and eight a saving. Two owners of soft coal plants thought the stokers did not diminish smoke, seven thought they did.

Circular No. 8 describes the result of a similar attempt to find what members who used economizers thought of their value. Of twelve replies seven were unqualifiedly in favor of economizers, while five were more or less unfavorable.

Circular No. 9 is a report on the "Efficiency of Combustion in a Boiler Furnace." It is chiefly a theoretical discussion, and will be found of interest to students, but contains also many practical suggestions which may be of benefit to the boiler user. The author of the report, Mr. R. S. Hale, states that ordinary firing is apt to get 10 to 20% worse results than the best skillful firing, the low results being generally caused by using too much air, but often by getting poor combustion.

THE SIBERIAN RAILWAY EXTENSION IN CHINA.

In the February "Consular Reports" Consul-General John Karel, of St. Petersburg, gives the following items concerning the extension of the Trans-Siberian Railway through China. As originally located the Trans-Baikal and Amoor section of this road was laid down from Chita, through Svetensk, on the shores of the River Shilka, to Pokrovskaia; thence along the north shore of the River Amoor to Khabarovsk, and then south to Vladivostock. The engineering difficulties along this line were very great, as 1,105 miles would have cost an average of about $77,000 per mile. Investigation showed that the road could be much cheapened by locating it through Manchuria, from about Lake Baikal, and negotiations were commenced with the Chinese government, and these were favored by political circumstances.

As a result, the Chinese government, on Aug. 27, 1896, gave a concession to the Russo-Chinese Bank, and to a specially organized company, called the Eastern Chinese Railway Company, to construct and operate a railway within Chinese territory. This association was sanctioned by the Czar on Dec. 16, 1896, and by imperial ordinance issued Dec. 23, 1896. The new railway is to extend from a point on the western frontier of the Province of Heilung Chang to a point on the eastern frontier of Kivin, and to connect with the branches of the Trans-Siberian Railway yet to be built. With the permission of China, the company may also work coal and other mines in the territory in question. The concession lasts 80 years, and shares can only be held by Russian and Chinese subjects. The stock capital is fixed at $2,570,000, issued in shares of 5,000 paper rubles, or $2,570 each, with such further capital in bonds as the Russian Minister of Finance may authorize. The company is to begin work in August, 1897, and must complete the road in six years. The total length of the Manchuria line is 1,273 miles, from the Onon station of the Trans-Baikal line to Nikolsk station on the South Ussuri Railway. Of this line 945 miles will be in Chinese territory. The old line, along the Amoor, between these two stations, was 1,614 miles long; the saving in distance alone is thus 341 miles, and in parts the new line will be nearly 400 miles further south and through a much better country.

In the same "Consular Reports" Mr. G. C. Monaghan, U. S. Consul at Chemnitz, presents some estimates of Siberian Railway traffic. He fixes upon July 1, 1904, as the date of completion of the Siberian Railway, and says that trains will probably be running to the Amoor River by 1898; and with fast steamers and the completed section of the South Russian Division of the railway, the trip to Vladivostock could be made from there in 18 hours. This would make 17½ days from London to Vladivostock, on the Sea of Japan. German engineers estimate that this time can be reduced to 9 days 2 hours, after the road has been in operation for several years, and is fitted for high rates of speed.

The present journey between London and Vladivostock can now be made by sea in 28 to 38 days, and 90% of passengers will doubtless prefer the land trip. It is said that first-class tickets from London to Vladivostock are to cost about $119; while a ticket to Japan, via Brindisi and the Suez, now costs $428. To the land price must of course be added the cost of sleeping berths for 12 nights and the living expenses.

WEATHER TABLE FOR JANUARY, 1897. (Furnished to Engineering News by the Department of Agriculture.

	Stations.	Temperature. (Degrees Fahrenheit.)				Wind.			Precipitation—rain or melted snow—inches.		
						Velocity in miles per hour.		Direction at time of max. velocity.			
		Average.	Max.	Min.	Range.	Average.	Max.		Total.	Heaviest in 24 hours.	No. of rainy days.
Northern Cities.	Northfield, Vt.	16.2	51	−18	69	8.4	44	S	3.46	1.18	12
	Portland, Me.	23.6	51	− 8	59	8.5	36	N	4.09	1.54	8
	New York City	29.4	84	5	49	15.5	60	NW	3.51	1.78	11
	Pittsburg, Pa.	27.4	63	− 7	70	7.7	34	W	1.34	.29	15
	Chicago, Ill.	21.8	57	−20	77	18.7	62	W	4.53	1.24	16
	Omaha, Neb.	20.9	51	−13	64	8.7	29	N	0.87	.34	9
	St. Paul, Minn.	9.4	49	−26	75	8.3	30	NW	2 13	.76	11
	Duluth, Minn.	9.4	43	−29	72	10.1	38	NW	1.48	.41	11
	Bismarck, N. Dak.	5.8	42	−30	72	10.7	47	NW	1.11	.52	8
	Average.	18.2	51	−16	67	10.7	42		2.50	.90	11
Southern Cities.	Washington, D. C.	31.0	64	8	56	8.5	40	NW	1.98	1.04	10
	Louisville, Ky.	32.0	69	4	73	11.8	46	SW	3.29	1.15	12
	St. Louis, Mo.	30.6	64	− 2	66	12.5	50	W	3.75	1.65	13
	Savannah, Ga	48.2	71	17	54	9.0	28	W	1.49	.95	9
	Kansas City, Mo.	27.4	64	− 4	68	9.5	37	NW	2.66	.98	11
	Jacksonville, Fla.	52.1	76	21	55	7.2	25	SW	1.89	1.06	7
	Chattanooga, Tenn.	38.6	64	6	58	8.8	34	SE	3.06	.70	9
	New Orleans, La.	51 1	74	23	51	10.5	40	SE	1.92	.50	11
	Memphis, Tenn.	39.4	68	10	58	12.1	46	SE	4.63	1 77	9
	Palestine, Tex.	45.2	78	11	67	7.3	27	SE	5 95	1 87	12
	Average.	39.6	69	9	61	9.7	37		3.06	1.17	10
Western Cities.	Helena, Mont.	20.8	49	−24	73	4.9	40	SW	0.80	.32	8
	Port Angeles, Wash.	39.1	56	19	37	4.7	30	SW	1.77	.46	15
	San Francisco, Cal.	48.6	60	40	20	6.8	37	SE	2.26	1.08	8
	Salt Lake City, Utah.	28.8	48	9	39	3.6	15	S	1.16	.32	11
	Santa Fe, N. Mex.	27.4	48	− 1	49	6.0	24	NE	1.11	.32	9
	Denver, Colo.	26.6	59	−14	73	7.1	45	NE	.58	.50	4
	Yuma, Ariz.	55.2	73	39	34	6.7	34	SE	2.83	2.16	8
	Average.	35.2	56	10	46	5.7	32		1.50	.74	9

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CHAS. W. REINHARDT.....CHIEF DRAFTSMAN.

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The Senate committee has inserted an item in the Sundry Civil Appropriation bill, providing for the making of further surveys of the Nicaragua Canal, not the sum of $350,000, which the commission recommended, but the sum of $150,000. We wonder if the same Senators who were so anxious to pass the bill guaranteeing the bonds of the Canal Company to the amount of $100,000,000 are the same ones who are responsible for cutting down this appropriation to less than half the amount recommended! Of course the bill has still to run the gauntlet of the Senate as a Whole, of the House and of the conference committees. It is to be earnestly hoped that in the course of its travels it may encounter some Congressman intelligent enough to insist that the item shall be increased to the full amount which the Commission recommended.

It ought to be apparent to any one of ordinary intelligence that if the United States is to practically furnish the funds to build the canal, it ought to take pains at the outset to see that the best route and the best plans for every part of the work are adopted. This is emphatically a place where cheap engineering would be dear as a gift. A very slight error of judgment in the design of any of the principal works of the canal might increase its cost by more than the entire amount recommended for the engineering work. How absurd would it be for the nation to send an engineering commission to Nicaragua and say to them in effect: "Go and examine this enterprise in all its details and advise us what it will cost to build this work in the best and most economical plan; but no matter how necessary investigations and surveys may be to settle doubtful points, don't spend more than $150,000. Learn what you can with that, guess at the rest, and report your conclusions."

The only excuse we can make for the Senate committee is that it may possibly intend the amount of the appropriation to cover the current fiscal year's needs only. If this is the case, however, it appears still to be mistaken economy. If an engineering commission is to be sent to Nicaragua to settle once for all the questions of final location and plan of construction, it ought to know at the start that ample funds were at its disposal for its work, and not be obliged to make plans for its work on a scale inadequate to the demands. If an engineering commission can be trusted to advise the nation as to the wisdom of expending a hundred million dollars on an enterprise, it could surely be trusted to conduct its own expenditures with honesty and economy and spend no greater part of the appropriation made for them than was actually necessary for its work.

The importance of correct and truthful surveys of public lands, and the costly litigation which will surely follow bungling work is well illustrated in a suit just commenced by the City of Spokane, Washington. It seems that about 1880 a government survey was made of a tract of land which included the bed of the Spokane River in front of the present city of that name. Instead of running meander lines, defining the banks of the stream as their instructions required, the surveyors treated the bed of the river as dry land and ran their lines directly across the stream. The Deputy Surveyors who ran these lines, Messrs. J. M. Glover and S. G. Havermale, then made locations and obtained deeds for this land, including the bed of the river, at the Spokane Falls, from President Hayes. These deeds cover, therefore, the water-power of the Spokane River at this point, and they have been since acquired by corporations and individuals by purchase from the original grantees. The value of the privileges thus transferred may be estimated by the fact that when the city was considering the project of purchasing a water right in the river for the purpose of maintaining a city pumping station, the owners demanded $300,000 for the right. The City of Spokane now claims title to the river-bed and the water-power on the grounds that the conveyance and patents of Glover and Havermale are illegal and without authority. It will be held that the President of the United States had no right to make such a patent, as the property was merely held in trust by the Federal Government during territorial times for the new state. As the river at this point "will float a saw log," it is held that it is a navigable stream under past rulings of Judge Beatty and of the Supreme Court. The defence of the owners is the patent from President Hayes, for all the territory in question. The property now in the hands of innocent purchasers is estimated to be worth about $1,000,000, and costly litigation to both parties and a heavy loss to one party will doubtless result from the careless or dishonest work of these government surveyors some sixteen years ago.

In commenting in our issue of Feb. 18, upon the experts' report favoring the running of through cars over the Brooklyn Bridge, we urged that the best financial arrangement between the Bridge Trustees and the elevated and street railway companies would be for the former to turn over to the latter all the burden of railway traffic across the bridge and thereby reduce the bridge operating expenses to a mere trifle of what they now are.

The "Brooklyn Citizen" reprinted our editorial and commented on it as follows:

> The only dissent from this conclusion we have to make is in the shape of the suggestion that, as has been stated on a previous occasion, there will probably be no sensible reason for the maintenance of the cable plant after the electric current shall have been used for the propulsion of the elevated as of the surface cars for a sufficient length of time to prove its efficiency and reliability.
>
> There will be no more need of a cable on the bridge part of the railroad than on any other part; for, the bridge platforms will be simply two stations on the entire line of the elevated roads, and the surface car passengers will not use them. In view, therefore, of the expected adoption of the third rail system now in use on the bridge by the elevated roads of New York, we may expect that the same will be adopted by the elevated roads of Brooklyn, so that the cars of both cities can be operated by it from Coney Island to the Bronx; and as a cable plant is not wanted on any other part there will be no call for one between the two bridge stations, and that great expense of bridge operation will be done away with.

We have no doubt that with the introduction of electric traction on both Brooklyn and New York Elevated Railways and through connection between them across the bridge, there will be a strong influence exerted to dispense with the cable railway altogether. Whether it would be either economical or safe to do so is a question which could be positively answered only after a careful investigation made by competent engineers, to ascertain all the facts in the case.

So far as the economy is concerned, however, a very simple computation, which anyone can understand, shows that the saving in power which the cable railway makes amounts to a very large money saving per annum. The weight of a 4-car loaded bridge train is about 120 tons, and every such train has to be lifted a vertical distance of 70 ft. in its passage from one terminal of the bridge to the center of the span. By the new system of operation it is proposed to reduce the time interval between trains to 45 seconds during the rush hours, or for from five to six hours per day. Of course during the middle of the day the interval will be considerably longer. Suppose we assume, however, that the total number of trains which will cross the bridge daily will be equivalent to a continuous traffic at a 60-second interval for 10 hours per day. Since a train weighs 120 tons or 240,000 lbs., and one train on each track passes the summit on the bridge every minute, the total power expended in lifting the trains against gravity alone will be per minute: $(240{,}000 \times 70 \times 2)$ ft.-lbs. $= 33{,}600{,}000$ ft.-lbs., or dividing by 33,000 we have in round numbers 1,000 HP., as the work that must be done to lift the trains over the grade. But the power which must be developed at the power-house to do this effective work is probably nearly or quite double this, when we compute the losses in the power house engines and dynamos, in the electric circuit from this dynamo to the motor and back again, and in the motors on the cars and the gearing by which they transmit their power to the car wheels.

Taking the additional horse power required as 2,000 we have to deduct from this the loss in friction of the present cable railway system. Suppose this is 500 HP. Then the total extra power expenditure to move cars across the bridge by electricity is 1,500 HP. What is the total cost of a ten-hour-a-day horse-power per annum in Brooklyn? Suppose we set it at $70. Then the total saving in power by the operation of bridge trains by the present cable plant will be $105,000 per annum.

The above will make clear the simple process by which the economy of the cable system can be computed. Of course the figures we have taken are mere approximations and there are several minor elements that we have not mentioned, which should be included in an accurate computation. But the method by which the economy of the cable system can be determined will be plain from our illustration.

As to the safety to be gained by the use of the cable, this is certainly an important element of the problem. We discussed this matter in our issue of Oct. 17, 1895, and have since seen no reason to change our opinion then expressed, that the spacing of the trains apart by the cable in descending the long grades of the bridge railway is a feature of safety in the operation which it would be unwise to discard.

THE IMPROVEMENT OF THE APPRENTICESHIP SYSTEM AS A SCHOOL FOR MECHANICS.

"Everyone is depending upon everyone else to make the good all round mechanic, and when the present supply is gone there is going to be trouble in getting good help of this class, in fact the trouble is already felt."

We find the above sentence in one of a pretty formidable lot of papers and discussions on apprenticeship, which have recently collected on our desk;* and it is such a concise statement of a defect in the working of the apprenticeship system of to-day as well as of the real cause of the trouble that it serves admirably to introduce a discussion of the opportunities for possible improvement of this system as a school for skilled workmen.

Notwithstanding the rapid drifting of manufacturing into specialties, and the increasing use of machinery that reduces the necessity of skilled handicraft to a minimum in many industries, the skilled workman who knows his trade in all its branches and knows it well, is still a necessity. Moreover, he is going to be a necessity in the future. The observer who looks only on the surface and sees in a great factory for the manufacture of some complicated machine, women, boys and men who never learned any trade, tending auto-

*"American Machinist," Dec. 24, 1896, letters from 116 machinery builders regarding apprenticeship. Proceedings of Western Railway Club for October and November, 1896. Proceedings of Western Boundrymens' Association, 1896, special committee reports and numerous communications and discussions.

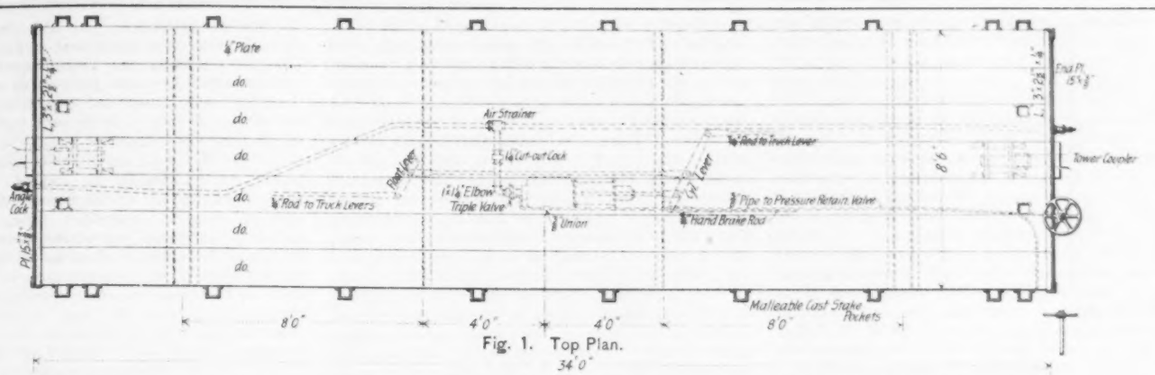


Fig. 1. Top Plan.

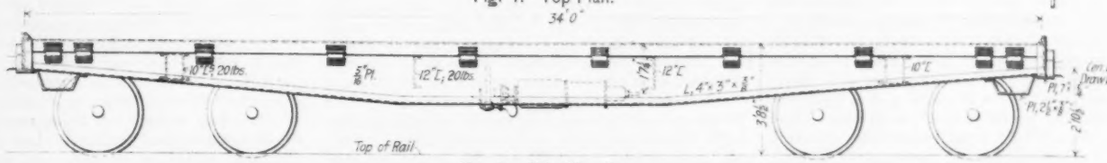


Fig. 2. Side Elevation.

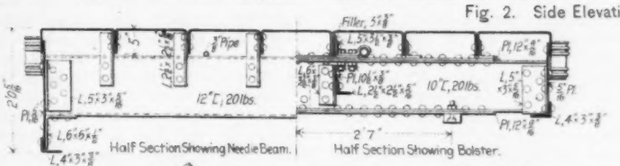


Fig. 3. Transverse Sections Showing Needle Beams and Bolsters.

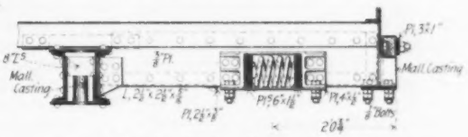


Fig. 5. Section Showing Draft Rigging.

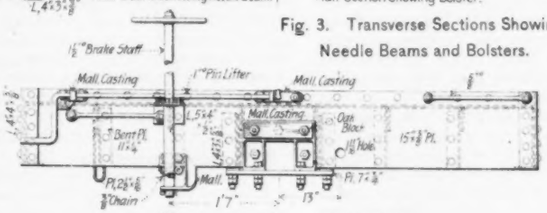


Fig. 4. Elevation of Brake End.

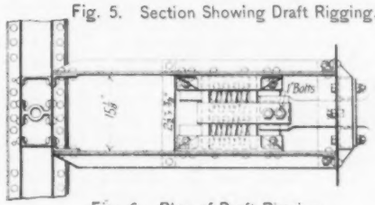


Fig. 6. Plan of Draft Rigging.

IMPROVED PENNOCK STEEL 80,000 LB. FLAT CAR.

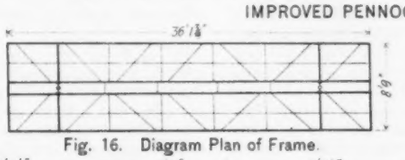


Fig. 16. Diagram Plan of Frame.

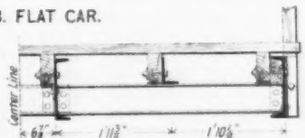


Fig. 15. Section Showing Needle Beam Bracing.

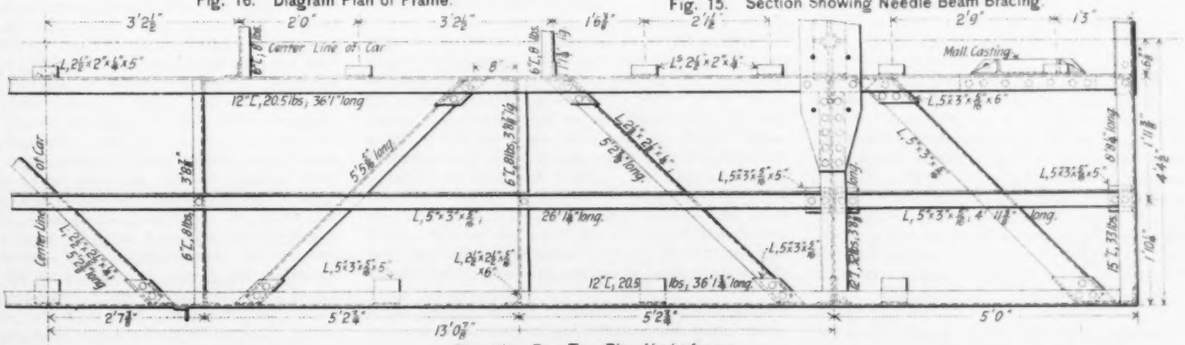


Fig. 10. Part Top Plan Underframe.

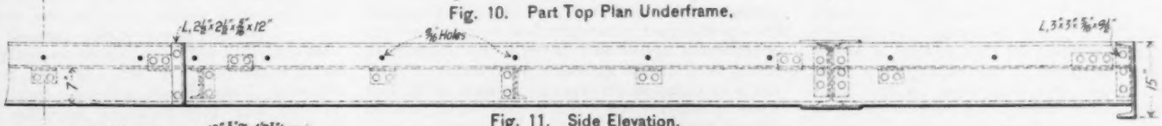
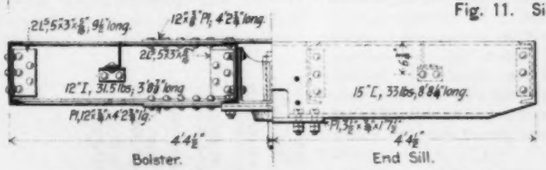


Fig. 11. Side Elevation.



Bolster. End Sill.

Fig. 12. Sectional Elevation Showing Bolster and End Sill.

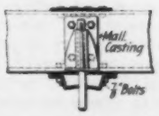


Fig. 13. Center Casting of Bolster.

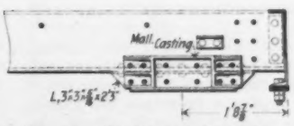


Fig. 14. Details of Draft Rigging.

STEEL UNDERFRAME FOR 40,000 LB. STOCK CAR.

STEEL CARS, UNIVERSAL CONSTRUCTION CO., CHICAGO, ILL.

D. W. Bowman, Chief Engineer.

CHAS. HART & SONS, LITH., 26 VESEY ST., N. Y.

matic machines for the production of special parts, may conclude that there is no more need of the all-around machinist; but all this automatic machinery has to be built, repaired, adjusted and closely supervised, and the mechanical engineer, in whose charge this work is placed, needs the highest class of skilled mechanics to carry out in the best possible manner his idea. Moreover, it is not every branch of manufacturing whose products can be turned out by the thousand or ten thousand in exact duplicate. A great proportion of the world's machinery, using the term in a broad sense, must be made to order. As a matter of fact, there is probably more than twice the demand for all-around mechanics to-day than there was a half century ago. We must conclude then that skilled workmen are a necessity and are to be a necessity of the future. How is the supply of such workmen to be maintained?

The apprenticeship system, as is well known, had its origin with the mechanics and trades' guilds organized so extensively in the twelfth century to protect the tradesmen and craftsmen of those days against the oppression of the nobility and their retainers. Each trade and craft had its guild and a guild was made up of master workmen, journeymen workers and apprentices. The boy entering a trade worked seven years as an apprentice and then became a journeyman worker at liberty under certain regulations to sell his labor where he desired or to become a master workman and employ apprentices and hire labor himself. If we weed out the tangle of trade interests and regulations which existed between these mediaeval guilds and which have no bearing on industry as it is organized to-day, we see the fundamental motive of the apprenticeship system to have been a pedagogical one, to train up skilled workmen to supply the ever-increasing demand of the mechanical crafts. The master workman was bound as firmly to make skilled workmen of his apprentices as they were to serve him faithfully. Between the two there was a relationship almost as personal and intimate as between a father and son,and from it there resulted the highest perfection, probably, that the apprenticeship system has ever attained as a school for skilled workmen.

It would be time and space consumed to little purpose for our present discussion to trace, step by step, the slow evolution by which this paternal association of master, journeyman and apprentice in the mechanical crafts was superseded by the impersonal, capitalistic association of to-day, but in a broad way the change was due to the gradual development of those conditions which to-day demand large concentrations of capital and the most elaborate division of labor in order to meet the stress of competition in cheap production. Now, whatever the advantages of these latter-day conditions of industry—and no one can question but that they are enormous—they do not easily adapt themselves to the personal and educational relationship which is necessary to the highest development of the apprenticeship system. We know that they have been made so to adapt themselves in many instances and we thoroughly believe that they can be so adapted in nearly all instances; but all this is aside from the fact we wish to impress here, which is that inherently the impersonal, capitalistic organization of industry at the present does not naturally secure a personal relationship between employer and employee.

In our valued contemporary, "The American Machinist," of Dec. 24, 1896, we find statistics of present practice regarding apprenticeship collected from 116 different manufacturing and railway companies. These statistics we have summarized with a few additional calculations in the accompanying table:

	Total No. of firms.	Take apprentices.	Discontinued.	Find system satisfactory.	Have written agreement.	Retain portion of pay or require bond.
Builders of stationary and marine engines, pumps, etc	37	27	3	24	9	10
Machine tool builders	35	25	1	24	18	14
Locimotive builders and railway companies	25	32	1	20	8	5
Miscellaneous machinery	19	11	2	10	5	4
Total	116	85	7	78	40	33

The table shows that 73% of the firms heard from take apprentices, and of them 92% express themselves as more or less satisfied with the system. There is evidently use for the apprentice boy in a very large proportion of American manufacturing firms engaged in machinery building, unless these figures are entirely unreliable, which there is no reason to think is the case. But going a little further it will be seen that only 47% of the firms taking apprentices enter into a written agreement with them and only 38% protect themselves by bonds or by withholding a percentage of the boy's salary until the end of his term of service. It also appears from our contemporary's statistics, although not shown in the above table, that there is almost no uniformity of practice in the educational requirements, wages paid, methods of instruction, or proportion of apprentices taken to total working force. Generally, too, as far as the information shows, careful and systematic inquiry into the applicant's character, education, and aptitude for mechanical work is not made except by a comparatively few firms. Few firms also seem to have any established proportion between the number of their apprentices and the total number of their working force. Of the 65 firms which gave the term of service required of apprentices, 21 required three years' service, 33 four years' service, 5 five years' service, and the remaining 6 indefinite terms between three and five years long. Practically all firms appear to pay apprentices small day wages from the beginning and gradually increase these wages each year the apprenticeship continues.

Evidently present practice upholds the apprenticeship system as a desirable thing by a large majority, and we see no prospect that anything can take its place. The trade school has been much talked of as a possible substitute for the apprentice system; and there is no doubt whatever that is a most valuable adjunct of the system, and is capable of being developed so as greatly to aid in the solution of the apprenticeship problem, but such a development is still a mere future possibility, and even if it is brought about, it is the general belief that more or less training in actual shopwork will still be necessary before a boy will be able to rank as an efficient journeyman worker.

It follows then that the employer of skilled labor is compelled to provide to a greater or less extent a training for such labor. He is confronted by exactly the same condition that the mediaeval guilds encountered, the necessity of teaching his craft in order to provide craftsmen upon whom to draw for his supply of skilled labor.

It is an accepted truth in the business world that to make a mutual business obligation between two persons continued and successful, each must be assured of getting his dues. If, therefore, the apprenticeship system is to prove of the most value, the employer must be assured that his apprentice will work his full term, will do his duties honestly and intelligently, and will endeavor to progress in skill and worth. The apprentice, on the other hand, is entitled to assurance that the employer whom he serves will furnish him good instruction in the craft he desires to learn, and will treat him in general with all the fairness and consideration that the employer himself demands from the apprentice.

We are now ready to consider what would seem to be the principal means to these two ends. Summarized these are: 1. A definite schedule of physical, educational and character requirements for candidates, with a term of probation to determine their aptitude for mechanical work; 2. A limitation of the number of apprentices taken to a reasonable proportion of the total number of workmen employed; 3. A comprehensive and binding form of indenture; 4. A diversified and carefully regulated course of shop training; 5. A course of special and general education to supplement the shop training. The assertion of these requirements logically demands a statement of the reasons upon which they are based, and these are briefly as follows:

1. Much of the success in holding an apprentice faithfully to his agreement depends upon the mental, physical and moral nature of the boy. If the boy is honest, industrious, ambitious and mentally alert, comparatively little trouble will be had with him. It therefore follows that the employer should first assure himself as certainly as possible that these qualities exist either latently or actively in the apprentices he takes and then strive by all practical means to increase and develop them. The common practice in determining the qualifications and aptitude of applicants for apprenticeship positions is generally loose and indefinite. In some shops a regular educational and physical examination is required, and a careful investigation is made into the habits, morals and disposition of the applicants, but usually the only precaution taken is "to get good healthy boys who behave themselves," which may mean little or much. It is found, however, that those firms who do have some definiteness and rigidity in their requirements always speak favorably of this practice, and many others who do not have such requirements are disposed to think "it might be a good thing."

A definite system of requirements tends toward good in two ways: (1) It gives the employer some assurance that he is securing good material to make into a workman; (2) it gives the boy a standing and a sense of worth and responsibility which are powerful incentives toward progress. But it is entirely necessary that such examinations and investigations be administered with good judgment, and with a proper sense of true worth of the material for the product desired rather than with rigid insistence upon lip knowledge and Sunday-school records. Besides the duty which the employer owes to himself to select the best material for his workmen, he owes it to the trade of which he is a member and to society as a body to discourage illiteracy and incompetency of mind and hand among his craftsmen.

2. All labor unions of skilled workmen advocate a restriction of the number of apprentices which shall be employed to a definite proportion of the total number of workmen. Their advocacy of this policy is based upon: (1)The desire to surround the apprentice with such conditions as will best promote his acquirement of a thorough knowledge of a trade; (2) the desire to restrict the supply of workmen so as to insure to them a fair remuneration for their labor, and also continuity of employment. It is evident that we have in these expressions of policy the making of an almost endless discussion of the abstract questions of ethics and economics, for which there is no space here. From the standpoint of the skilled workman—call it an arbitrary one if you wish—it is evident, however, that the restriction of apprentice labor demanded by him will act to produce the results he desires, viz., a high standard of skill, and continued employment and adequate remuneration for that skill. This will appear more clear from the considerations further on.

3. A formal indenture of apprenticeship is advocated by most labor unions and by many employers, although many employers also claim to have found little advantage in its use. It may be questioned, however, whether this last result has not been largely due to the fact that the document has no legal standing and little respect as a binding contract, the violation of which is dishonest. If every firm required a formal indenture and held its apprentices to its observance, would the document not assume a power which it may not have now? For example, suppose foundrymen prepared and agreed to use universally an indenture for each branch of the molding trade which provided for a definite division of work, a definite restriction of apprentices taken, a definite scale of wages, a definite code of requirements for applicants and definite code of discipline, would it not seem that an importance and forcefulness would be given to such a document which would make it valuable in holding both employer and apprentice to a just sense of their respective obligations? Foundrymen very generally contend that it would. Indeed, the Western Foundrymen's Association has appointed a committee to draw up a complete indenture of this character, with the purpose of urging its universal adoption. Further, we find Mr. Martin Fox, Chief Officer, of the Iron Molders' Union, saying:

> I lay particular stress on a comprehensive and binding form of indenturing apprentices as being the surest way to maintain the standard of efficiency and skill required of the American mechanic.

Similar expressions from both employers and labor unions will be found all through the discus-

sions mentioned at the outset of this article, but the essential point to be noted here is that all labor organizations and many employers of labor favor a written and specific indenture in preference to a verbal agreement.

4. After all the preceding considerations are made, however, we confront the fact that the real essential of apprenticeship as a vehicle for developing an efficient all-around workman is a carefully regulated course of shop training. In this the necessary things are, first, personal instruction, and, second, diversity of labor. This becomes clear the moment we accept the proposition that the chief end of the apprenticeship system is to develop skilled mechanics, and not to earn the greatest profit for the employer during the apprenticeship term. It is wholly a distortion of truth to contend as some persons do that this means the turning of the factory into a trade school. It means simply a recognition of the fact that the apprentice is in the shop to be taught a trade and that every means that the practical exigencies of business will allow shall be employed to this end.

Returning to the two necessary features of an efficient shop training for a general mechanic just named, we can see with but a moment's thought why both are essential. Personal instruction is to a large degree recognized as an essential principle of all pedagogical training, although it is less necessary in some classes of instruction than others. In "book-learning," to use a common expression, it is perhaps least necessary; in skill of handicraft perhaps the most necessary, although even in the latter a bright boy will "pick up things" from merely observing his fellow-workers, even if no one directs his efforts. From an examination of the evidence presented in recent discussions, by the way, one is impelled to believe this method of absorption is pretty often the only system of training which the apprentice undergoes. Of course, personal instruction means a personal instructor, and under actual conditions of shop practice this instructor must be some one or more of the older workmen. Unless these men are employed to do nothing else but teach, which is seldom the case, the amount of time at their disposal for teaching is very limited, and here we find the necessity for restricting the number of pupils, they have to instruct, if each one is to get the attention he needs. Diversity of labor, however, is even more important than personal instruction in developing an all-around mechanic from the apprentice. The truth of this is so obvious almost as to need no argument to prove. The greatest difficulty in securing this diversity to-day comes from the tendency of manufacture to specialties, and piece work.

5. If it is admitted that a certain degree of education is desirable in the applicant for apprentice training, the desirability of continuing that education during his service is also evident. This is always easy to secure to a beneficial measure by encouraging attendance at night schools, and of individual study and reading, and it is no great expense or task for employers to start classes and night schools of their own. We find that quite a number of employers have done this, and generally they express themselves satisfied with the results.

LETTERS TO THE EDITOR.

Rainfall on the Pequannock, Croton, and Sudbury Drainage Areas, 1892 to 1895, Inclusive.

Sir: I enclose a table, showing the amount of rainfall, amount yielded and amount wasted, on the Pequannock, Croton and Sudbury watersheds, for the past five years. The yield of the Sudbury watershed in 1895, you will notice, was abnormal, due to an extraordinary rainfall, and freshet in the Sudbury River, at a time when the rest of the Atlantic seacoast was suffering from a drought. You will also notice how much less the quantity lost from the Pequannock watershed is than the quantities lost from the Croton and the Sudbury watersheds; and this is what explains the better yield of the Pequannock watershed.

Yours very truly,
Clemens Herschel,
Superintendent East Jersey Water Co.

2 Wall St., New York, Feb. 8, 1897.

Rainfall, Yield and Waste of Water, in Inches, on the Pequannock, Croton and Sudbury Drainage Areas, 1892 to 1896, inclusive.

	Pequannock.			Croton.			Sudbury.		
Year.	Yield.	Rainfall.	Quantity lost.	Yield.	Rainfall.	Quantity lost.	Yield.	Rainfall.	Quantity lost.
1892	21.598	37.319	15.721	17.06	45.37	28.31	16.456	41.830	25.374
1893	32.647	49.029	16.382	29.92	57.83	27.91	21.774	48.225	26.451
1894	28.249	42.663	14.414	22.56	46.96	24.40	16.182	39.740	23.558
1895	19.072	35.084	16.012	18.87	38.33	19.46	24.196	50.620	26.424
1896	30.060	50.506	20.446	21.88	48.10	26.22	[illegible]	43.070	21.620

Weir Tables for Measuring Water for Irrigation.

Sir: I thank you for the copy of Engineering News of Dec. 3, 1896, containing the weir tables for measuring water used for irrigation.

My opinion is that this is a step in the right direction, far ahead of the old practice of using a miner's inch as the basis. At the same time, weirs will require careful attention under experienced men.

Changes of temperature and exposure are liable to test the efficiency of weirs after a while. I have thought that regular sluice gates would serve the purpose better than almost any other contrivance. We are able to measure the flow through several sluice gates here, with satisfactory results, and the advantages of gates would be in the stability and simplicity of construction.

Tables or diagrams of the discharge of gates of any particular form and under any opening of gate would serve to regulate the flow desired. Very truly,

James Francis.

Office of the Proprietors of Locks and Canals on Merrimack River, Lowell, Mass., Feb. 16, 1897.

The Business Chances of Engineering Graduates.

Sir: I have read with interest the letter by R. L. Donald, on "Experiences of Some Recent Graduates," and your comments thereon, which were published in your issue of Feb. 18. As you point out in your comments, Mr. Donald makes some incorrect deductions, and I wish to emphasize that point.

With a wish to give all honor and credit to the Civil Engineering Department of Cornell University, I must still suggest that Mr. Donald is too sweeping in his statement that "It is very improbable that Cornell's record can be duplicated." There are several of the older engineering colleges whose records I know equal that which has been quoted, and I am inclined to the belief, derived from a considerable study of the subject, that the Cornell record is not far from the average record of the first-class engineering colleges of equal age. In one of the engineering schools of the Central West, with which I am well acquainted, the record is as follows: About one-third of the engineering graduates now stand in the first three divisions of the Cornell list, about one-third in the next three divisions, and about one-third in the last three divisions. This school is considerably younger than that of the Cornell department. An examination of the Engineering News, Oct. 13, 1892 (page 354), will also show that this record is not far from the average amongst all engineering graduates, as far as is known.

I am not blind to faults in our engineering schools, nor to the mistake which is sometimes made in endeavoring to put students through engineering courses who do not have the native ability, industry, or feeling of responsibility for their work which are essential to success in the engineering profession; yet the evidence stands strongly in favor of the engineering schools which are properly administered, as is shown by the final records of their graduates. A college cannot make an engineer, but it can, and many do, put the students in a fair way to become good engineers.

* * *

Madison, Wis., Feb. 27, 1897.

A Restriction of Interstate Commerce.

Sir: I note in recent advertisements for bids for work on the New York state canals, that with reference to cements, it is stated that "Those manufactured in this State will be given the preference, provided they satisfactorily pass the test."

This strikes me as an exhibition of selfishness unworthy of the great Empire State. What is the ultimate result of such a spirit of discrimination? If it is proper for cements, why not for other products, engineers' services as well? If proper for New York State, why not for other States, and if for the State why not for the municipality? The result would be that every man would be obliged to confine his energies, whether in selling a manufactured product or his services, to his own immediate vicinity.

That it is a public work does not seem sufficient justication, for why should not private corporations as well as the State be loyal to State interests, if such discrimination may be called "State Loyalty?"

It is fair to presume that the specified tests are not more severe than the favored manufacturers approve of. As similar requirements with respect to other materials or labor are not insisted upon, it is probable that the cement manufacturers planned to build a fence about the State to keep out other cements. Should this fence prove inaccessible both for ingress and egress, who would suffer most?

Many other sections of this country in common with New York State recently voted for "Reciprocity" and "Protection," but we of the West did not understand that the former was to be restricted to international, and the latter to be applied to interstate affairs.

This criticism is based on broad grounds, as I am in no wise interested in the manufacture or sale of cements.

Yours very truly,
Chas. F. Loweth,
94 East 4th St., St. Paul, Minn.

Feb. 24, 1897.

(It is a question whether the restriction above noted could be sustained if it were attacked in the United States courts. These have uniformly and wisely held that States cannot so legislate as to interfere with the freedom of commerce between the several States.—Ed.).

Concerning the Public Land Surveys.

Sir: In your issue of Feb. 18 appears an article from the pen of Mr. Francis Le Baron upon the "Contract System of United States Land Surveying," and an editorial upon the same subject.

I have no desire to discuss this subject or to defend a system which has so many patent faults, but I beg to call Mr. Le Baron's attention to the fact that the Manual of 1881 is no longer the guide for the Deputy Surveyors, nor is the system of public land surveying burdened with the many faults which he ascribes. In 1894 the Commissioner of the Land Office issued a Manual of surveying instructions, the preparation of which was the work of scientific men, and connected with the Surveying Division of that office is a corps of educated civil engineers whose duties are to examine all public surveys, both in the field and as to the returns. Assuming a contract system as unavoidable, these men have certainly so changed and improved what the system once was that the best results possible are now had. If Mr. Le Baron or the editor of the Engineering News will read the last annual report of the Commissioner of the General Land Office it will be seen that this officer and his subordinates have made every possible effort to transfer the work of executing the public surveys to the Coast or Geological Survey.

The power to make such a change rests with Congress alone and back of Congress is the influence which, finding some satisfaction from the present system, strenuously opposes any alteration.

A casual glance at the duties of the Commissioner of the General Land Office will show that the surveying of the public lands is a very small fraction of the business of the Bureau over which he presides, and the requirement that he should be a civil engineer to properly fulfill the duties of his office, as well as the charge that the continuance of the present contract system is a serious reflection upon the intelligence of the officials in charge, were, I am sure, not intended, and will be promptly corrected.

Very respectfully,
An Examiner of Surveys in the General Land Office.

Washington, D. C., Feb. 19, 1897.

(As to the requirement that the Commissioner of the Land Office should be a civil engineer, it still seems to us that so long as any important part of the duties if this Commissioner relate to civil engineering it would certainly be well that he, as well as his staff, should be familiar with engineering work. The letter of Mr. Hinsdale below and the receipt of a copy of the new Manual of 1894, convince us that the present expert staff in the Land Office is doing all it can, under present controlling conditions, to correct the evils of past practice, and we are glad to correct any statements in our editorial that may have given a contrary impression. But from the letters published herewith it is evident that further improvement is still needed, and the best disposition of the whole business seems to be the transfer of all the scientific and technical work of the Land Office to a purely technical bureau; either to the Coast or Geological Survey, as suggested by the Commissioner of the Land Office; or, better still, to a new bureau, or department controlling all government scientific work.—Ed.).

Sir: I was forcibly impressed with the article of Mr. Le Baron on "Experiences with the Contract System of U. S. Land Surveys in Florida," as well as with your editorial in the same issue of your journal. While I do not wish to criticise either the article of the gentle-

man in question, or your able editorial, which, by the way, expresses the truth in a great many ways, still I think that the management of the public land surveys is not fully comprehended in either of the two criticisms.

The contract system of bidding on surveys to be executed, under the General Land Office, is not conducted in the same manner as similar work would be under any engineering scheme. For instance, the maximum rates are fixed by law, and range from $3 for sub-division, $5 for township and standard and $7 for meander lines in an open country, to extreme rates of $12, $18 and $23 per mile on account of mountains, brush, timber, etc. The Deputy Surveyors, while they bid on the work to be done, have a limit to their prices set in one direction, but they almost invariably sum up the total amount of cost for the survey at about the same figure. For while one will bid a little lower on township lines, he will make a higher bid for sub-division and meander lines, and vice versa. If two or three Deputies bid, they will nearly all foot up to the same total, which will be just below the maximum price allowed to be paid. The Surveyor General will then select his man, and refer the same to the General Land Office for approval.

In most of the Western States, Deputy Surveyors, and good ones, particularly, are in demand, and within the past year the Surveyor General of one of the Western States had to ask that Deputies from outside his State bid on the work to be let.

One of the great disadvantages of taking these contracts is the time which elapses before the surveyor gets his pay. For example, a contract will be let, say, on April 1; the Deputy's bond will not be approved until June or July, and by the time he gets into the field it will be August. He will not be able to finish his work until October, or, perhaps, November, which will be too late in the season in most cases to have it examined; and he will have to wait until the following spring before the examination in the field can be made. Even then the returns (plats and field notes), together with the examiner's report, will have to await their order for office examination in the General Land Office, and it will be fully a year, in most cases, before the surveyor receives his pay; unless, as the case often is, the Deputy can secure the services of a Senator or Member of Congress to have his contract made special, or to otherwise push his interests..

The field examinations referred to above are made in three different ways. First, by special examiners, usually political appointments made by the Secretary of the Interior; second, by clerks detailed from the Division of Public Surveys of the General Land Office, and, third, by men appointed by the U. S. Surveyor-General. The last method is used the least, and is the most unsatisfactory, as one Deputy, perhaps, will examine another's work, and he, in turn, examine the first Deputy's work; in such cases neither show errors.

It is a lamentable fact that politics are allowed to enter into the system at all, for where good engineers are once secured for these offices they should be retained. While I do not agree with you that the Commissioner of the General Land Office should necessarily be an engineer, I do maintain that the U. S. Surveyor-Generals, the Chief of the Division of Public Surveys and most of the employees should be engineers. At the present time I know of but two Surveyor-Generals who are engineers or surveyors, and of the whole force in the General Land Office the representatives of the engineering profession can be counted on the fingers of one hand.

Regarding the price paid for surveys, which you contend is too small, I will state that Deputy Surveyors consider it very poor work when they do not clear from 25 to 50% of the total amount of their contract price; where they fall behind this percentage it will be generally found that this result is due to poor work or to poor management.

As regards the ability and intelligence of the force of the General Land Office, or, rather, the Division of Public Surveys, which, by the way, consists of about 18 employees, and has the entire regulation of the public survey system, I think you have misjudged them somewhat. In the first place, they are all classed as clerks, there being no appropriation for either engineers or surveyors, and they form a technical division in a clerical department.

A bill was presented to Congress last year asking for a special force of ten Examiners of Surveys, and during the past two years other bills have been presented asking that the government be allowed to make its own surveys; all of which bills were quickly turned down by Congress on account of the political advantages of the present system.

Regarding the Manual of Surveys, it was revised again in 1894. Your humble servant was one of three performing the work; and although it is far from being perfect, under the adverse surroundings that were presented, it was better than could be expected.

Very respectfully,

T. R. Hinsdale, C. E.,

Division of Public Surveys, Gen'l Land Office.

Washington, D. C., Feb. 23, 1897.

Sir: The article entitled, "Experience with the Contract System, Etc.," of Feb. 18, voices the concurrent opinion of engineers who are familiar with the undesirable results of the system. From a wide experience in several states the author believes that all manner of errors and inaccuracies are to be expected and good work is exceptional. In the mountainous districts indisputable evidence of fictitious notes of subdivisions never made are not unusual. Occasionally corners may be set in the valleys, but how, or why set as they were, is often beyond finding out. The recorded notes and plats may tell but little due to their location; the topography shown may be almost wholly imaginary and distances may be one half mile or more in error. In the arid plains large areas are almost, or wholly, devoid of corners, and the notes serve merely to demonstrate the author's brilliancy in the field of fiction. All this, while sufficiently harassing, would be simply an annoying detail of practice but for the inflexible rigidness of the Department of the Interior in the requirements relative to procuring rights of way across public lands. These requirements are of comparatively recent growth, in spite of the accumulated evidence of scores of years, that possibly the original work of subdivision and the recorded notes of the same may be grossly erroneous. These requirements serve to greatly retard improvements by vexatious and unnecessary delay and expense. See "Regulations Concerning Right of Way for Canals, Ditches and Reservoirs, approved Feb. 20, 1894."

Section 19 demands the distance to the nearest existing corner on each township or section line crossed: Section 23 says: "No field notes will be accepted unless the lines on which the monuments are set conform to the lines shown by the field notes of the survey as made originally under the direction of this office." As a matter of fact, surveys showing the actual location of corners, or topography, at variance with that upon the government plats, although in accordance with the truth, has been deemed sufficient cause for non-approval of the plat filed, or for pigeon-holing the same to be resurrected only with great difficulty.

It is plainly often impossible for the engineer to make the required affidavit as to the accuracy of the plat, and also to get it approved, save, possibly, by long and may be fatal delay, costly investigation and overwhelming evidence that the original subdivision was in error. Engineers acquainted with the profound apathy and inertness of a bureaucracy will understand what this means.

And, to say the least, it is difficult to make the notes of a line crossing a section conform with the government notes showing a section of quite a different size, and at the same time to make the actual length of the line and the calculated co-ordinates all agree. It is an almost impossible problem to cause the platted line to fit in with the imaginary topography upon the government plats; and to then make solemn oath that the whole is accurate.

Absurd as these requirements may seem to the ordinary individual, the Interior Department, in its wisdom, has actually demanded them. It is submitted that a plat showing the actual location of such lines, corners, streams, etc., as could be found, and bearing the engineer's affidavit as to the accuracy of the same, and that other contiguous corners and lines were not found, after diligent search, should be sufficient. As yet, all personal protest, argument and presentation of existing facts seem to have but little, if any, effect.

Respectfully,

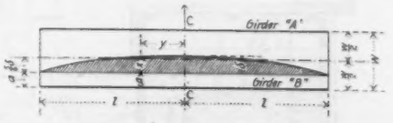
W. B. Lawson.

504 McPhee Block, Denver, Colo., Feb. 24, 1897.

A NEW FORMULA FOR SO LOCATING TWO PLATE GIRDERS RELATIVE TO A CURVE AS TO BRING EQUAL LOADS TO EACH.

By Henry Szlapka.*

Let A and B represent the girders of a deck-plate girder span.



Let w be the width between centers of girders and let δ be the middle ordinate of the curve. Let q be the unformly distributed live load per lineal foot of bridge; if concentrated loads are used, let it represent the equivalent uniform load derived from the maximum bending moment as if the span were on a tangent. Let x and y be the co-ordinates of any point on the curve in reference to the axis CC, and the chord of the curve. Then the element of load carried by girder A at any point will be

$$dA = q\frac{(x+a)\,dy}{w} = q\frac{a\,dy}{w} + q\frac{x\,dy}{w}$$

Then the reaction R_A will be the sum of all the elements, dA, on half the span, or

$$R_A = \int_0^l q\frac{a\,dy}{w} + \int_0^l q\frac{x\,dy}{w} = q\frac{al}{w} + \frac{q}{w}\int_0^l x\,dy \quad (1)$$

Now, $\int_0^l x\,dy$ equals half the area included between the curve and its chord. For all practical purposes we can assume the curve to be a parabola, and thereupon put $\int_0^l x\,dy = \frac{2}{3}\,\delta l$.

Equation (1) then becomes

$$R_A = q\frac{al}{w} + \frac{q}{w} \times \tfrac{2}{3}\,\delta l \quad (2)$$

The bending moment at the center of girder A equals the product of the reaction R_A by one half the length of the span minus the product of one-half the load which girder A carries by its lever arm. As equation (1) shows, the load carried by A can be considered as made up of two parts, one part $\frac{qal}{w}$ being proportional to the area enclosed between the chord and girder B, and acting with the lever arm $\frac{l}{2}$, the other $\frac{q}{w}\int_0^l x\,dy$ being proportional to the area enclosed between the chord and the curve and acting, according to the assumption of a parabola, with a lever arm of $\frac{3}{8}$ l.

We can then write the bending moment

$$M_A = R_A\,l - q\frac{al^2}{2w} - \frac{q}{w} \times \tfrac{2}{3}\,\delta\,l \times \tfrac{3}{8}\,l \quad (3)$$

Substituting the value of R_A from equation (2) and reducing, we get

$$M_A = q\frac{al^2}{2w} + \frac{5}{12}\frac{q\delta\,l^2}{w} = q\frac{l^2}{2}\left\{\frac{a+\frac{5}{6}\delta}{w}\right\} \quad (4)$$

If the bridge had been on a tangent and both girders carried equally we would have had

$$M'_A = \frac{ql^2}{2} \times \frac{1}{2} \quad (5)$$

As our object is to find how to place the girders so as to carry equally, we make equation (4) equal to (5), giving

$$q\frac{l^2}{2}\left\{\frac{a+\frac{5}{6}\delta}{w}\right\} = q\frac{l^2}{2} \times \frac{1}{2} \text{ or } \frac{w}{2} = a + \frac{5}{6}\delta \quad (6)$$

This formula applies, strictly speaking, to plate girders without a cover plate only, but it is a very close approximation also in case of girders with plates, so that in practice we can in all cases of deck plate girder spans place the girders as shown by formula 6.

*761 East State St., Trenton, N. J.

REMOVAL OF PAINT FROM IRON AND STEEL SURFACES BY THE SAND-BLAST.

An interesting experiment on the removal of old paint, oxide and scale from the steel hull of the U. S. cruiser "Atlanta," by means of the Tilghman sand-blast apparatus, was made in the dry dock of the Brooklyn Navy Yard, on March 1. The test was made under direction of Messrs. Ward and Nash, of 23 Purchase St., Boston, Mass., general agents of the sand-blast machinery for the United States and Canada, and of Mr. John F. Honey, their New York representative, of No. 25 Whitehall St., New York city. The test was made in the presence of Naval Constructor Bowles and other officers of the Navy. The apparatus consisted of a Blake direct-acting air compressor, which furnished air at a gage pressure of 15 lbs. per sq. in., a small air tank or receiver, a sand tank, containing a hopper which delivered the sand to a nozzle in which the air came in contact with it, insuring a thorough mixture of sand and air, a 2-in. rubber hose about 30 ft. long, and a delivery nozzle with opening about ½-in. diameter. A portion of the steel hull of the vessel was marked off into spaces 5 ft. square, and the blast was applied by a workman who held the nozzle from 4 to 6 ins. from the surface. The hull appeared to have been originally well painted with a coat of red lead, and one or two coats of a dark colored paint which had been abraded in spots showing the red surface beneath. Several workmen were engaged in scraping the paint on other portions of the hull by means of ordinary scrapers, which removed entirely the outer coatings of paint, but only partially removed the red lead. The surface

of the steel was somewhat scarred and pitted, and it was not possible for the ordinary scraping tool to reach the bottom of the numerous depressions. When the sand blast was applied, however, not only were the outer coatings removed, but every trace of the red lead also, and likewise the black oxide on the surface of the steel itself, even to the bottom of the deepest pittings, exposing the clean gray metallic color of the steel. The degree of perfection of the work seemed to depend upon the skill of the workman. When he was careful to keep the blast long enough on every portion of the surface, it was made of a uniform light gray color throughout, but if in order to do more rapid work he moved the blast nozzle too rapidly, or was not careful to go thoroughly over every portion, the surface would show dark spots, due to the imperfect removal of the black oxide of iron. If he held the nozzle at an angle to the surface the sand would not strike the bottom of the pittings, which would appear as small black spots. The speed of the work was somewhat variable, three squares of 25 sq. ft. each being cleaned, respectively, in 16, 20 and 19 minutes, including a few short stoppages during each period, required for adjusting the flow of sand or for re-filling the sand hoppers. Two kinds of sand were used, one a white sand with many black specks, having the appearance of crushed granite, and the other a brown building sand. The latter was more uniform in grain, and in general finer than the former, and appeared to be capable of doing more rapid work. About a barrel of sand was used during the hour occupied by the test. The sand was not saved but was allowed to fall to the bottom of the dock, a considerable portion being blown into the atmosphere in the shape of dust. It was evident that the greater portion of the sand might have been saved and used over again. It also appeared that a larger sand nozzle might have been handled by the workman, so that the speed of his work might have been at least doubled. On the whole, the test was eminently successful, and we see no reason why this method of cleaning the hulls of steel vessels and other large surfaces of iron and steel should not meet with general adoption.

TESTS OF POHLE AIR LIFT PUMPS AT THE ROCKFORD, ILL., WATER-WORKS.

One of the most interesting installations of air lift pumps now in operation is that at the Rockford, Ill., city water-works. This plant was installed by the agents of the Pohle air lift pump under a guarantee to furnish a stipulated flow of water per 24 hours, and an extensive series of tests was made to determine whether this guarantee had been fulfilled or not. The trials and experiments continued over a period of nearly two years, and are described quite fully by Mr. Charles C. Stowell, City Engineer of Rockford, Ill., in a paper read before the Illinois Society of Engineers and Surveyors and in letters and records recently furnished to this journal. From these sources the following description is obtained:

In the fall of 1891, the city of Rockford, Ill., appointed two experts to act with the city engineer to investigate and report upon an additional water supply for the city. The most practical, and at the same time least expensive method was to drill artesian wells to the St. Peters rock only, and by means of a low lift pump in a shaft connected with the wells, to deliver the water from them to the pump pit and storage reservoir. Four 8-in. wells were drilled within a radius of 30 ft., with the idea of sinking a shaft in the center and connecting the wells with it. The shaft project was abandoned and an Aurora

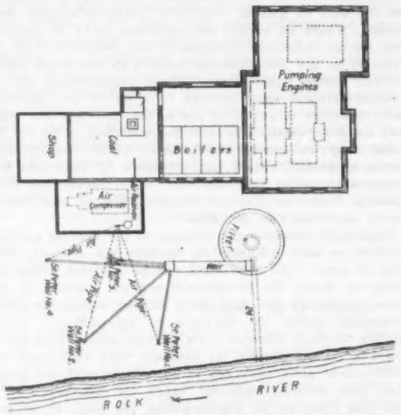


Fig. 1.—Plan Showing Arrangement of Air Lift Pumping Plant at Rockford, Ill.

deep well pump placed in each well. By this method about 150 gallons of water per minute were obtained from each well. This fell far short of the immediate demand for water. To extend the system of St. Peters wells meant expensive and complicated machinery, with the prospect in view of soon reaching the limit to which steam might be carried to operate the pumps.

At about this time the agents of the Pohle air lift pump made a proposition to the city to install machinery for the purpose of testing what the air lift system could accomplish toward relieving the trouble, and the proposition was accepted. Fig. 1 shows the relative final location of the wells and air compressor and the arrangement of the air and water delivery pipes. Mr. Stowell continues the description as follows:

The tests of the wells at Rockford began Sept. 20, 1893, with the Pohle pump, but none of the apparatus was in shape to give economical results. A small, straight line air compressor 12 × 16 ins. was set up near Potsdam well No. 4, and connected with a 2-in. air pipe which led down to the bottom of a 4-in. discharge pipe, and terminated in a 1½-in. pipe. The discharge pipe was submerged 91 ft. With an air pressure of 37 lbs. at the receiver, a flow over a weir of 352 gallons per minute was obtained. The well naturally yielded but 104 gallons. A 5-in. discharge pipe was substituted for the 4-in. and submerged 84 ft. The result was 538 gallons per minute. The discharge pipe was raised and the weir so placed that the water from it would be delivered to the pump pit, and not wasted. A wooden trough connected the two. Sept. 27 the compressor was again started and ran until Oct. 5. During this time the air pressure varied from 29 to 76 lbs., while the number of revolutions varied from 38 to 120. The percentage of submergence varied from 69% to 80%. The discharge seemed to vary in no proportion with the pressure and the number of revolutions of the compressor. It appeared that, beyond certain points, to increase the amount of air did not materially increase the discharge. Thus, when the number of revolutions was 120, the air pressure was 40 lbs., and the discharge 516 gallons per minute; with 90 revolutions and 37 lbs. air pressure, the discharge was 512 gallons per minute; with 48 revolutions and 38 lbs. air pressure, the discharge was 452 gallons per minute. The pipes were lowered 50 ft. further without materially increasing the flow except at high speeds.

At the suggestion of Mr. D. W. Mead and the City Engineer, the air pipe was then used in the well without any discharge pipe, except the casing. First, 180 ft. was used with the result of increasing the flow to 804 gallons, with 80 revolutions and 64 lbs. air pressure; next, 108 ft. was used with a flow of 739 gallons; next 60 ft. was used with a flow of 498 gallons. Then 100 ft. of 1¼-in. and 50 ft. of 2-in. pipe were used, making 150 ft. in all. With 125 revolutions and 50 lbs. pressure the same results as before were obtained, namely 804 gallons per minute; with 70 revolutions and 48 lbs. of air pressure, but 572 gallons was obtained; 225 ft. of air pipe was next tried and the best result produced was 869 gallons. The pipe was shortened to 205 ft., and with 150 revolutions and 70 lbs. air pressure, 936 gallons was produced. Tests were then made in one of the St. Peters wells with the air pipe 201 ft. in the well and no discharge pipe except the well casing, and obtained 350 to 400 gallons per minute.

On the strength of these experiments Mr. Alexander E. Schnee, the general agent for the Pohle air lift pump, made a contract with the city to put in a plant, guaranteeing to pump 2,000,000 gallons per 24 hours from the four St. Peters wells, or lower the head of water 85 ft. below the surface of the ground, the nominal head being 6 ft. below the surface. They were to have all ready for a final test by June 1, 1894. The test showed about 1,500,000 gallons. Since then various schemes have been resorted to to complete the contract and secure settlement. But until recently (Jan., 1896), they have not been able to pump more than three of the wells at the same time. Nozzles of various sizes have been resorted to but to no purpose. When the attempt would be made to pump four wells one or another would drop out, perhaps to begin again, and another would drop out. It could not be predicted which one would stop.

In the spring of 1895, an expert, Mr. W. S. Titus, was sent to Rockford in the interests of the air lift. He condemned the Pohle plan and used open air pipe with slots about ⅛-in. wide and 18 ins. long near the lower end. He concluded that the air was wasting through the rock without producing any effect. Following this 6¼-in. casing was put in each well to a depth of 250 ft., and the air pipe 1½ ins. in diameter 245 ft. The air discharge opening was ⅝-in. in diameter at the end of a return bend. The four wells were pumped without trouble, and about 1,800,000 gallons delivered to the required height. The old weir was too small for the work and the velocity of the water was not sufficiently checked before reaching the spillway. A new and larger weir was made which gave good satisfaction.

As the quantity of water was so near the required amount it was decided to change the opening in the nozzle to ½-in., but when one of the pipes was taken out for that purpose, it was found to have lost its nozzle, and consequently had been discharging air through a 1⅛-in. opening in place of one of ⅝-in. No difficulty had been experienced in operating this well with the other three, and the difference was not discovered until the pipe was taken from the well. To satisfy all parties, a ⅝-in. nozzle was placed on the pipe and returned to the well and all the wells again pumped. Less water was obtained than before. Taking a hint from this, the return bends were removed from the air pipes in two of the wells and the ends capped. Twenty ¼-in. holes were drilled in the last 14 ins. of each air pipe. The results from pumping these two wells only were compared, which showed slight increase in the discharge.

It was thought by some that the submergence must be in the same proportion in all the wells and that the openings for the discharge of the air must be the same, but this idea was shown to be false; first, by the accident to one of the pipes changing the size of the opening from ⅝ to 1⅛-ins.; and second, by the difference in the head of water in these wells when pumped at the rate of 1,800,000 gallons per 24 hours. One was 60 ft. below the surface; the second, 78 ft.; a third, 82 ft.; and a fourth 85 ft.

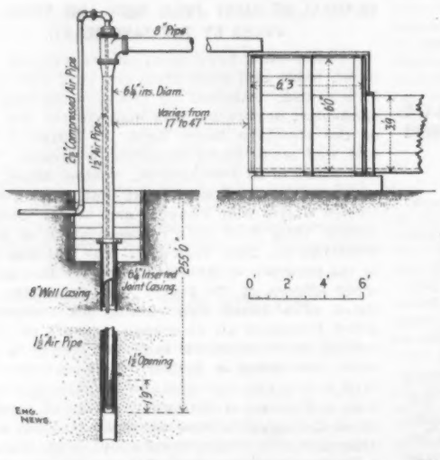


FIG. 2.—METHOD OF PIPING WELLS FOR AIR LIFT PUMPING, ROCKFORD, ILL.

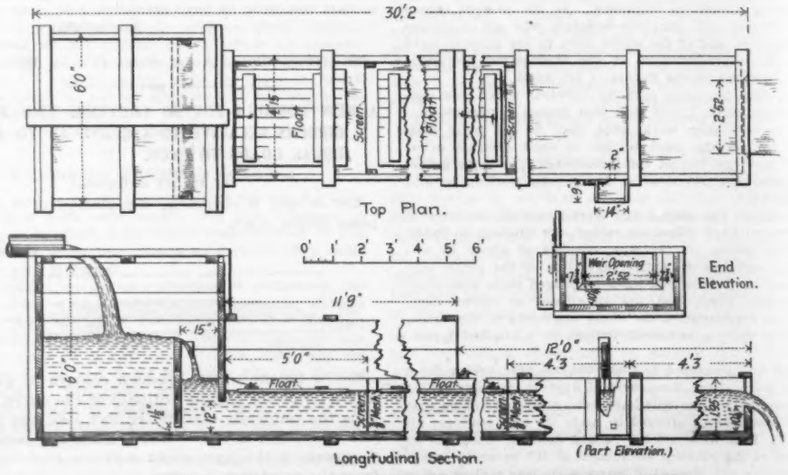


FIG. 3.—DETAILS OF MEASURING WEIR FOR AIR LIFT PUMP TESTS, ROCKFORD, ILL.

Table Showing Results of Tests to Determine Capacity of Pohle Air-Lift Pumping Plant at Rockford, Ill., Water-Works.

Date.	Time.	Revolutions of comp.	Air pressure.	Steam pressure.	St. Peter Wells, distance from top of ground to water. No. 1. ft.	No. 2. ft.	No. 3. ft.	No. 4. ft.	Weir reading, width of weir, 2.52 ft.	Flow: Gallons per min.	Flow: Gallons per 24 hrs.
Feb. 6, 1896*	1:15 p. m.	99	79.0	84.0	81.0	81.5	79.5	59.0	.534	1,408.8	2,028,728
	2:15 p. m.	98	77.5	81.0	82.0	83.0	80.5	59.0	.5285	1,382.0	1,990,101
	3:15 p. m.	100	77.0	77.0	83.5	84.0	82.5	59.0	.532	1,401.1	2,017,676
	4:15 p. m.	100	76.5	76.0	84.0	84.5	82.5	59.0	.5305	1,395.4	2,009,401
	5:15 p. m.	99	76.5	82.0	84.0	84.0	82.5	59.0	.5305	1,395.4	2,009,401
	6:15 p. m.	100	76.0	81.0	84.0	84.5	82.5	59.0	.5345	1,410.7	2,031,494
	7:15 p. m.	..	..	..	83.5	84.0	82.5	59.0	.534	1,408.8	2,028,728
	8:15 p. m.	100	76.5	..	83.0	84.5	82.5	59.0	.5335	1,406.9	2,025,964
	9:15 p. m.	100	76.5	80.0	84.0	84.5	83.0	59.0	.533	1,405.0	2,023,200
	10:15 p. m.	100	76.0	82.0	84.0	84.0	83.0	59.0	.5335	1,406.9	2,025,964
	11:15 p. m.	99	76.0	80.0	83.5	84.0	82.5	59.0	.5345	1,410.7	2,031,494
	12:15 a. m.	97	76.0	78.0	84.0	85.0	82.5	59.0	.532	1,401.1	2,017,676
	1:15 a. m.	96	76.0	81.0	84.0	84.5	82.5	59.0	.532	1,401.1	2,017,676
	2:15 a. m.	95	76.0	82.0	84.0	84.5	82.5	59.0	.532	1,401.1	2,017,676
	3:15 a. m.	95	76.0	82.0	84.5	84.5	82.5	59.0	.532	1,401.1	2,017,676
	4:15 a. m.	93	76.5	81.0	85.0	85.0	83.0	59.0	.529	1,383.9	1,992,865
	5:15 a. m.	95	76.5	81.5	84.5	84.5	83.0	59.0	.530	1,393.5	2,006,639
	6:15 a. m.	95	76.0	81.0	84.0	84.5	82.5	59.0	.535	1,412.7	2,034,261
Feb. 7, 1896.	7:15 a. m.	95	76.0	81.0	83.5	85.0	82.5	59.0	.5315	1,399.2	2,014,916
	8:15 a. m.	..	..	..	83.0	84.5	82.5	59.0	..	.....	.....
	9:15 a. m.	..	..	..	84.0	84.5	82.5	59.0	.5303	1,394.6	2,008,295
	10:15 a. m.	96	76.0	81.5	84.5	84.5	82.5	59.0	.529	1,383.9	1,992,865
	11:15 a. m.	95	76.0	79.0	85.0	85.0	83.0	59.0	.531	1,397.3	2,012,156
	12:15 p. m.	95	76.0	81.0	85.0	85.0	82.5	59.0	.532	1,401.1	2,017,676
	1:15 p. m.	95	76.0	81.0	83.5	85.0	83.0	59.0	.532	1,401.1	2,017,676
	2:15 p. m.	95	76.0	81.0	84.5	85.0	83.0	59.0	.529	1,383.9	1,992,865

*At 12.30 p. m. all four St. Peter Wells were started.

Note.—Weir readings are an average of the highest and lowest reading. The formula used for calculating the flow was $Q = 3.33\frac{1}{6}(L - 0.1\,n\,H)\,H^{\frac{3}{2}}$, where n = end contractions; H = weir reading, and L = 2.52 ft.

Having reached this point the agents of the Pohle air lift pump made a proposition to the city to make a final test of 24 hours, the city to pay only in the ratio of the water obtained to the 2,000,000 gallons first guaranteed, if they failed to make the water fall below 85 ft. from the ground surface, but if they did that or secured the full 2,000,000 gallons, to pay the full amount of the original contract. The result of this test was that a flow of 2,016,628 gallons per 24 hours was secured.

The apparatus used and methods adopted in making this final test were as follows: The 14 × 22-in. duplex Rand air compressor pumped into a reservoir from which a 2½-in. pipe ran to each well. To this pipe a 1½-in. pipe was connected and continued down inside the 6¼-in. well casing as shown by Fig. 2. This drawing in connection with Fig. 1 also shows the arrangement of the discharge pipes, of which there were, of course, four, one from each well, all discharging into a weir constructed as shown by Fig. 3. The depth of water below the surface in the wells was recorded by means of wooden floats attached to steel tapes.

The accompanying table shows the discharge as measured every hour, the steam and air pressure, depth of water in the wells and other data obtained. The average of 25 weir readings was 0.53181 ft., or a discharge of 2,016,628 gallons per 24 hours. In Fig. 4 are shown four of the indicator diagrams taken, two from the air and two from the steam cylinder, with such appended data as is needed to explain them.

As these cards were taken at the times when the pump seemed to be doing the best it is interesting to compute as accurately as possible the efficiency shown. Taking Diagram I. it will be seen that 124.33 I. HP. was developed. The table shows the discharge to have been at the rate of 2,017,676 gallons per 24 hours, or 1,401.1 gallons per minute at this time, while the lifts were 84 ft., 84.5 ft., 82.5 ft. and 59 ft. from the four wells, to which must be added 7.5 ft., the height of the discharge pipe above the surface. Assuming that the amount of water obtained from each well was the same we have:

$$\frac{85 \times 1{,}401.1 \times 8.34}{124.33 \times 33{,}000} = 23.9$$

The system thus showed an efficiency of about 24% under the assumptions made, or in other words about one-fourth of the power developed in the steam cylinder was actually used in lifting water from the wells.

While this may seem a low efficiency, it is to be remembered that the efficiency of any other deep well pumping system is very low, on account of the numerous losses of power between the steam cylinder and the point where force is applied to raise the water.

It is to be noted also that the above is merely a rough approximation based on assumptions which, in some respects at least, were not fulfilled. The flow from the different wells, for example, was not the same, that from the well in which the head was least reduced being noticeably larger than in either of the others.

Taken as a whole the tests described are chiefly valuable as adding to the very meager information regarding the actual efficiency of the air lift pump, rather than for any definitely conclusive results which they present. In Engineering News of July 12, 1894, a description was given of an air lift pump test made at De Kalb, Ill., but owing to imperfect condition the results obtained were likewise inconclusive. This seems to be the characteristic of all information yet made public regarding the air lift system of pumping, and it is to be hoped that some of the promoters of these devices or the engineers in charge of them will strive to place the matter on a more accurate basis.

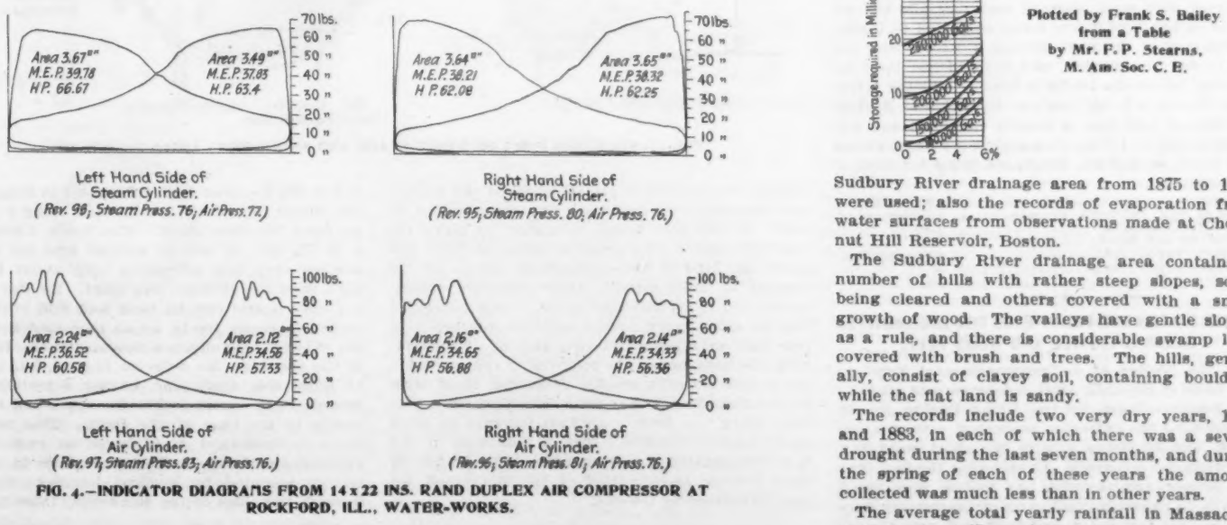

Area 3.67" M.E.P. 39.78 H.P. 66.67
Area 3.49" M.E.P. 37.83 H.P. 63.4
Left Hand Side of Steam Cylinder. (Rev. 98; Steam Press. 76; Air Press. 72.)
Area 3.64" M.E.P. 38.21 H.P. 62.08
Area 3.65" M.E.P. 38.32 H.P. 62.25
Right Hand Side of Steam Cylinder. (Rev. 95; Steam Press. 80; Air Press. 76.)
Area 2.24" M.E.P. 36.52 H.P. 60.58
Area 2.12" M.E.P. 34.56 H.P. 57.33
Left Hand Side of Air Cylinder. (Rev. 97; Steam Press. 83; Air Press. 76.)
Area 2.16" M.E.P. 34.65 H.P. 56.88
Area 2.14" M.E.P. 34.33 H.P. 56.36
Right Hand Side of Air Cylinder. (Rev. 96; Steam Press. 81; Air Press. 76.)

FIG. 4.—INDICATOR DIAGRAMS FROM 14 x 22 INS. RAND DUPLEX AIR COMPRESSOR AT ROCKFORD, ILL., WATER-WORKS.

DIAGRAM FOR ESTIMATING THE REQUIRED STORAGE CAPACITIES FOR RIVER DRAINAGE AREAS.

By F. S. Bailey.

The accompanying diagram will be found useful for estimating the amount of water which a drainage area or reservoir will supply in extremely dry seasons.

It is plotted from a table on p. 348 of the Twenty-second Annual Report of the State Board of Health of Massachusetts, the table being contained in an article on the selection of water supplies, by Mr. Frederic P. Stearns, M. Am. Soc. C. E., then Chief Engineer of the Board.

In preparing the table the records of the flow of the Sudbury River and of the rainfall upon the Sudbury River drainage area from 1875 to 1890 were used; also the records of evaporation from water surfaces from observations made at Chestnut Hill Reservoir, Boston.

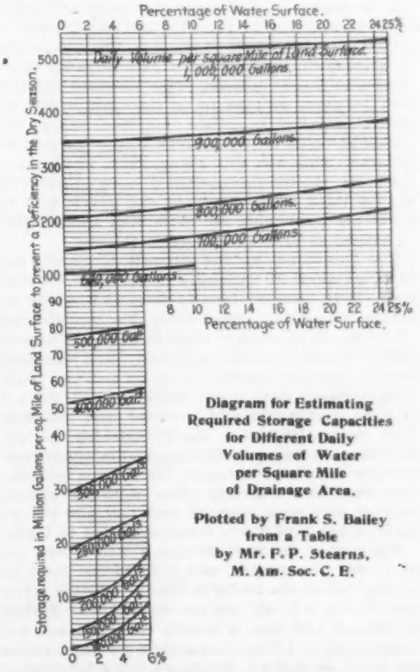

Percentage of Water Surface.
Daily Volume per Square Mile of Land Surface 1,000,000 Gallons.
900,000 Gallons.
800,000 Gallons.
700,000 Gallons.
600,000 Gallons.
500,000 Gallons.
400,000 Gallons.
300,000 Gallons.
200,000 Gallons.
150,000 Gallons.
100,000 Gallons.
Storage required in Million Gallons per sq. Mile of Land Surface to prevent a Deficiency in the Dry Season.
Percentage of Water Surface.

Diagram for Estimating Required Storage Capacities for Different Daily Volumes of Water per Square Mile of Drainage Area.

Plotted by Frank S. Bailey from a Table by Mr. F. P. Stearns, M. Am. Soc. C. E.

The Sudbury River drainage area contains a number of hills with rather steep slopes, some being cleared and others covered with a small growth of wood. The valleys have gentle slopes, as a rule, and there is considerable swamp land covered with brush and trees. The hills, generally, consist of clayey soil, containing boulders, while the flat land is sandy.

The records include two very dry years, 1880 and 1883, in each of which there was a severe drought during the last seven months, and during the spring of each of these years the amount collected was much less than in other years.

The average total yearly rainfall in Massachusetts is about 45 ins.; the rainfall for the years 1880 and 1883 was 38.18 and 32.78 ins., respectively.

The results given by the diagram will not apply, of course, to drainage areas which are radically different in character to the Sudbury, or to localities where the average annual rainfall is much more or less than 45 ins., without making some allowance for the differences. The practical application of the diagram may be more clearly under-

stood by giving an example. Let us assume that it is desired to know the yield of a pond having an area of 0.15 sq. mile and an available storage capacity of 225,000,000 gallons, which has draining into it 1.5 sq. miles of land surface. The amount of storage in this case would be equivalent to 150,000,000 gallons per square mile of land surface, and the water surface would equal 10% of the land surface. By looking down the line headed 10% it will be seen that a storage of 150,000,000 gallons per square mile corresponds to a daily volume of 660,000 gallons per square mile, equal to 990,000 daily for the whole drainage area.

CONCRETE SIDEWALKS IN SAN FRANCISCO.

In an article on engineering work at San Francisco, Cal., in our issue of Nov. 26, 1896, reference was made to the very general use of concrete sidewalks, and we have recently received some details of this construction from Mr. George P. Wetmore, of the contracting firm of Cushing & Wetmore, making a specialty of concrete and artificial stone work.

The cost of the best Portland cement at the present time is $2.50 per barrel, averaging 4.3 cu. ft. packed, or 4.7 cu. ft. loose. The foundation of sidewalks in the residence districts is usually 2½ ins. in thickness, composed of 6 parts of crushed rock of size not to exceed 1 in., and 2 parts of beach gravel to 1 part of cement. The top portion is ½-in. thick, composed of 1 part screened beach gravel to 1 part cement. This company recently had occasion to take up a sidewalk which the owner said had been laid for five years, and which had only begun to break within the past six months. This was only 1⅞-in. thick at its thickest point, the top being nothing more or less than a good thick wash of cement and gravel and the lower portion having not more than about 1 part of cement to 12 or 14 of other materials.

The foundation for the sidewalk is usually laid in strips about 10 ft. long, and the width of sidewalk (15 ft. usually), tamped down and having top portion placed on it immediately. The top is leveled off by means of straight edges and is at once gone over with steel trowels and fairly well smoothed down. After getting the initial set and first troweling it stands until it becomes quite stiff, when it is gone over again and troweled and polished. This method is called "hard" finishing, as distinguished from one troweling, and is almost universally followed. It makes the surface less slippery than one troweling. The work is usually covered with sand, watered each day and left for eight or ten days before being subjected to traffic.

The cost of the work averages 9 to 10 cts. per sq. ft. for 3-in. paving, and 12 or 14 cts. for 4-in. paving, where the traffic is heavier. In the latter case the top is from ¾ to 1 in. in thickness. A gang of three or four men is usually employed and will average 150 to 175 sq. ft. per man per day. Prices are about as follows, the wages being for days of 9 hours:

Cement	$2.50 per barrel.
Crushed rock, delivered, average	1.75 per cu. yd.
Gravel for foundation	1.40 " " "
Gravel for top finish	1.75 " " "
Finisher wages, best	40 cts. per hour
Finisher helper, best	25 " " "
Laborers, best	20 " " "

SMOKE STACKS AND FRONT-ENDS FOR LOCOMOTIVES BURNING LIGNITE AND WOOD FUEL.

In the "Notes of a Transcontinental Trip" in our issue of Sept. 17, 1896, reference was made to the position taken by the Union Pacific Ry. in abandoning the extension smokebox with straight stack, and replacing it with the short smokebox and diamond-top stack. Considering the fact that the former arrangement has had a very rapid growth on railways in all parts of the country during the past few years, and is in fact now the almost universal arrangement for new engines, while the diamond stack is very generally considered as an old-fashioned and obsolete device, we thought it worth while to investigate the matter with some care and to ascertain the reasons for the present practice and the details of construction adopted. Full information on this subject was furnished to us by Mr. J. H. McConnell, Superintendent of Motive Power and Machinery, Union Pacific Ry., and has been made use of in the preparation of this article.

The character of the fuel used on the Union Pacific is the main reason for the somewhat unusual standard of practice on this road, the coal being a light, friable lignite, the sparks and cinders from which are readily drawn through the tubes when the blast is sharp. The coal is obtained from the company's mines in Wyoming. The following is an analysis of the coal obtained from four points in that State:

	Analysis of coal from Rock			
	Hanna.	Springs.	Almy.	Carbon.
	P. ct.	P. ct.	P. ct.	P. ct.
Fixed carbon	38.70	45.35	37.47	39.50
Volatile products	44.37	40.26	37.92	40.63
Moisture	8.72	10.46	15.01	7.37
Sulphur	0.66	1.25	0.79	1.63
Ash	8.21	4.02	9.10	12.50

The diamond stack (of the old-fashioned style) was first used on this road, but from 1885 to 1891 all the locomotives were equipped with the extension front and straight stack. It was found, however, that they threw fire and sparks very badly, much more than with the old arrangement (causing frequent fires along the line), while the spark arresting devices placed in the front end (either netting or perforated plates) checked the steaming capacity and increased the consumption of coal. It was also found necessary to make the exhaust nozzles very small in order to burn this particular kind of fuel successfully and to get the engines to make steam. After extensive experiments and trials had been made, it was concluded that no satisfactory results could be obtained with the then existing standards, and in February, 1891, the road began the removal of the extension parts and straight stacks, replacing them with diamond stacks. The records show that since that time there has been a gradual increase in train loads hauled, combined with a reduction in the fuel consumption per train mile. The figures of these records, as submitted by Mr. McConnell, we have tabulated as follows:

During the time when the extension smokebox was used the road did not confine itself to any one particular device or pattern, but experimented with every style of front-end then in service in different parts of the country. With all of these, however, the same results were obtained, and it was found uniformly impossible to control the escape of fire from the smokestack when the engine was steaming freely.

The present standard stack has a 17-in. cylindrical portion with a conical top about 4 ft. in diameter at its widest part, the outwardly flaring part being 18½ ins. high, and surmounted by another section 8 ins. high, the top diameter of which is 3 ft. 6½ ins. It will be seen that these proportions differ radically from those of the old type of diamond stack, the upper and lower cones of which were practically identical. The deflecting cone is set well up in the wide portion of the stack, and has a corrugated surface with horizontal faces tending to throw the sparks back into the throat of the stack. The netting is in the upper section of the stack. In the winter a 3 × 4-in. mesh, No. 9 wire, netting is used; while at the other seasons a 4 × 4, No. 9 wire, netting is used. The smokebox is 3 ft. 6¼ ins. long from tube sheet to front plate, the center line of the smokestack being 2 ft. 0½-in. from the tube sheet. The inside diameter is 4 ft. 7⅛ ins. It will be noticed that the nozzles are set very low, averaging only about 4½ ins. high from the exhaust pipe joint. By this means a longer nozzle can be used and still enable the engine to steam freely, as an increased height of the exhaust pipe means a decrease in the diameter of the opening. No deflector is used, but there is an adjustable draft pipe, having a petticoat end just above the nozzle, while the upper end reaches nearly to the base of the stack. This tends to cause a downward draft from the ends of the upper rows of tubes. The pipe slides in guides, and is operated by vertical handles extending through the sides of the smokebox, these handles

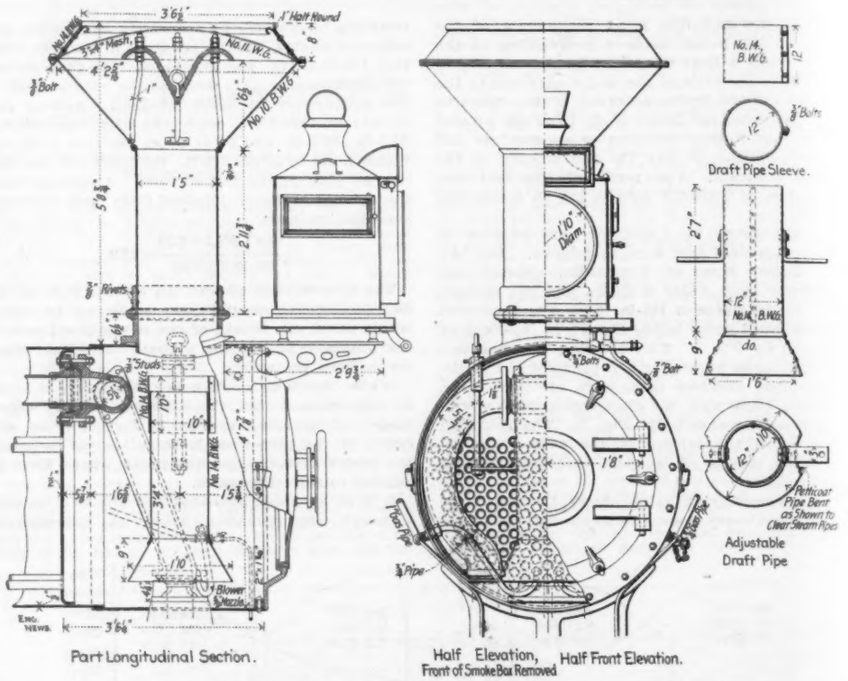

Part Longitudinal Section.
Half Elevation, Front of Smoke Box Removed
Half Front Elevation.
Draft Pipe Sleeve.
Adjustable Draft Pipe
Petticoat Pipe Bent as Shown to Clear Steam Pipes

FIG. 1.—STANDARD FORM OF SMOKE-STACK AND SMOKE-BOX; UNION PACIFIC RY.

	1890.	1891.	1892.	1893.	1894.	1895.
Average number of loaded freight cars per train	15.86	16.11	16.85	17.12	18.96	20.22
Average number of passengers cars per train	5.00	5.44	5.59	5.96	6.13	6.20
Number of loaded freight cars hauled 1 mile per ton of fuel	254	255	261	260	271	282
Number of passengers cars hauled 1 mile per ton of fuel	119	124	138	145	139	139
Tons of freight hauled 1 mile per ton of fuel	2,560	2,781	2,756	2,757	3,006	2,997
Pounds of coal burned per car-mile, all service	10.02	9.96	9.36	9.27	8.49	7.68
Number of engine trips	58,673*	244,550	248,200	225,570	205,130	.....
Number of trains delayed by engines not steaming	513*	560	354	265	234	...
Miles run per failure	114.37*	436.70	701.13	851.21	876.88	.....

* Three months (October, November and December); all engines then fitted with extension smokeboxes and straight smokestacks.

being held at any desired height by means of set screws. The construction of this stack, with the large opening at the top, makes the engines steam more freely and burn less coal than when fitted with a similar stack 4 ft. 2 ins. diameter at the widest portion and 2 ft. 10½ ins. diameter at the top. In Fig. 1 are shown the form of smokestack and smokebox as now used, and which was adopted in 1895. The past five years' experience in all kinds of service has demonstrated the superiority of the diamond-top stack (for engines burning this character of fuel) over the most approved of the various forms of extension fronts which have been tried, the superiority being both in steaming qualities and in fuel economy. The boiler pressure is 180 lbs. per sq. in.

The heaviest passenger trains average 12 to 15 cars, and are hauled by ten-wheel engines with

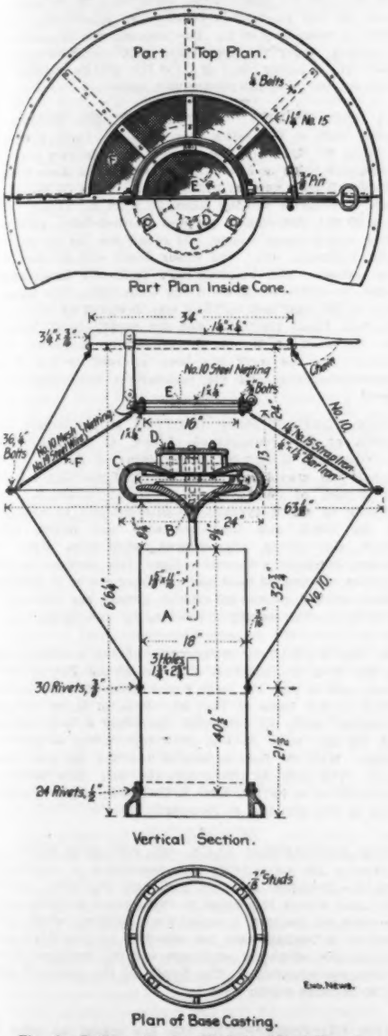


Fig. 2.—Balloon Smoke-Stack for Wood-Burning Locomotives; Southern Pacific Ry.

cylinders 20 × 24 ins., the diameter of driving wheels being 69 ins. for engines on the lines through Nebraska and 62 ins. for engines on the mountain grades in Wyoming, the grades between Cheyenne and Laramie being from 1.7 to 2.16%. The average speed between Omaha, Neb., and Salt Lake City, Utah, 1,032 miles, is 31 miles per hour. For the eastbound train, with 12 to 14 cars, the average speed between Cheyenne, Wyo., and Omaha, 516 miles, is 40 miles per hour. For the limited train, between Omaha and Ogden, engines of the eight-wheel type are used, having cylinders 18 × 26 ins., and driving wheels 69 ins. diameter. The time for this train is 29½ hours from Omaha to Ogden, or at the average speed of 36 miles per hour for the entire distance.

This road is not the only one which has found the diamond stack the best where lignite is used for fuel. The Canadian Pacific Ry. has had much the same experience, as noted in our issue of Sept. 17, but on that road the old style of diamond top is used, which is narrower and higher than the form now used on the Union Pacific Ry.

Where wood is used for fuel for locomotives a special form of smokestack is required, and we illustrate in Fig. 2 the construction of the huge balloon smokestacks for wood-burning engines on the Southern Pacific Ry. These engines are used only on the Shasta Division (San Francisco to Portland) and the lines in Oregon. The centre of the stack is formed by an 18-in. cylinder A, 3 ft. 4½ ins. high, which projects up into the double-cone or balloon top. Over the top of this cylinder is the spark deflecting arrangement B, C, D, which is so formed as to throw back the sparks into the space between the cylinder and the cone. Above the deflecting arrangement is a flat truncated cone F, of netting of No. 9 steel wire, No. 10 mesh. In the top of this there is a door E, 16 ins. diameter, operated by a lever extending across the top of the stack. The balloon part of the stack is 18 ins. diameter at the base (where it is riveted to the cylindrical stem), 5 ft. 3½ ins. diameter at the widest part, and 2 ft. 10 ins. diameter at the top.

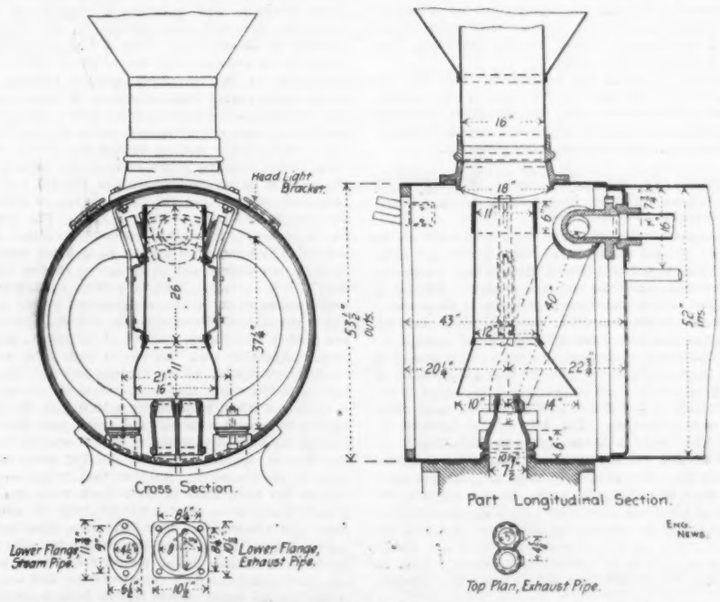


FIG. 3.—SMOKE-BOX OF WOOD-BURNING LOCOMOTIVES; SOUTHERN PACIFIC RY.

The total height from top of smokebox to top of stack is 6 ft. 6¼ ins. The smokebox, Fig. 3, has a double nozzle, set quite low, with a draft pipe extending nearly up to the base of the stack, this pipe having a petticoat end over the nozzles. The height of the draft pipe is adjustable, but not from the outside (as in the case of the stack of the Union Pacific Ry., above described.) Guides in the pipe are secured by bolts in slotted holes to two straps depending from the top of the smokebox, so that to adjust the pipe the door of the front end must be opened. The smokebox is 3 ft. 7 ins. long inside (from tube sheet to front plate), and 4 ft. 5½ ins. outside diameter. The particular smokestack and front end here shown are those of a Schenectady ten-wheel engine with cylinders 18 × 24 ins., for the drawings of which we are indebted to Mr. H. J. Small, Superintendent of Motive Power. It may be noted that on all other divisions of this road coal is used for fuel, and the engines have extension smokeboxes with straight cast-iron stacks, the diamond stack not being used.

A LARGE CAR FLOAT for the Pennsylvania R. R. is being built at the Nixon Shipyards, Elizabethport, N. J. It is to be 340 ft. long and to carry 28 loaded cars, the draft being 6 ft. 9 ins. The hull will be of steel; depth, 12 ft., with 18 watertight bulkheads, and a shelter shed over the entire length of the craft.

BOOK REVIEWS.

SKETCHES IN CRUDE OIL.—Some accidents and incidents of the petroleum development in all parts of the world. With portraits and illustrations. By John J. McLaurin, author of "A Brief History of Petroleum," "The Story of Johnstown," etc. Harrisburg, Pa., published by the author. 8vo.; pp. 406.

Commencing with the history of petroleum in ancient times and in all parts of the world, the author devotes the bulk of his book to the discovery and development of the petroleum industry in the United States. Many portraits of early discoverers, of modern promoters, and of those in some way identified with this industry, are reproduced; and scattered through the pages are numberless interesting reminiscences of the early days of oil-well sinking in this country.

THE ENGINEERING WORKS OF THE GODAVARI DELTA, (India.)—A descriptive and historical account compiled for the Madras Government. By George T. Walch, M. Inst. C. E., Chief Engineer for Irrigation, Madras (retired). In two volumes. Vol. I. Madras, 1896. Printed and published by the superintendent of the Government Press. 8vo.; pp. 165; with photo-engravings and plans and maps.

This volume describes the rectification, control and development for irrigation of the delta of the Godavari River, ranking next after the Ganges and Indus among the great rivers of India. It is 900 miles long and has a drainage area of 115,000 sq. miles, with a maximum discharge of 1,500,000 cu. ft. per second. The so-called delta includes all the alluvial lands lying along the banks of the two branches forming the delta proper, and it covers an area of about 2,000 sq. miles. The improvement of this delta, and its resultant increase in productiveness by means of a thorough system of irrigation canals, was determined upon by the Madras Government in 1844, as an outcome of the terrible famine of 1832-33, and the destruction of crops in following years by inundations. The improvement contemplated the embankment of the river, dams with irrigation channels, channels for surplus water and the raising of roads and the building of bridges. After a long discussion of means best adapted to the ends in view, actual work was commenced in 1846, under General, then Major, Sir Arthur Thomas Cotton, K. C. S. I. The author then details the progress of the work performed, giving general plans and illustrating results by photo-gravures of completed work. Under the head of irrigation, rules and rates are given for the application of water to lands, and the total cost of, and the revenue from the works, are also stated in detail.

ALTERNATING CURRENTS AND ALTERNATING CURRENT MACHINERY. By Dugald C. Jackson, C. E., M. Am. Soc. M. E., M. Am. Inst., E. E., Professor of Electrical Engineering, University of Wisconsin, and John Price Jackson, M. E., M. Am. Inst., E. E., Professor of Electrical Engineering, Pennsylvania State College. The Macmillan Co., New York. 8vo.; cloth; pp. 729; $3.50.

The authors state in the preface that the rapid progress in electrical engineering and the breadth of the subject have been the cause of incompleteness in many published works, and have sometimes resulted in a more presenting of results without reasons. The present work aims to avoid this. The same fundamental laws control the phenomena of alternating and continuous currents; and if care is taken to apply these, it will be found that the subject may, it is said, be clearly grasped and re-

duced almost to the simplicity of continuous current discussions.

It is a well-known fact, however, that the subject of alternating currents is considered one of the most difficult in the curriculum of an engineering school, and in many colleges it is not studied until the post-graduate year. A knowledge of differential equations is essential to the understanding of the work, and in the beginning a total of 73 symbols relative to electrical terms and conditions are enumerated for use in formulas and discussion. The work is so arranged that six of the fifteen chapters may be omitted, when the work is used as a text book. The first chapter deals with the electric pressure developed by alternators. It is especially noticeable that the early history of electrical development, so common in works of this class, is omitted.

The chapter on graphical and analytical methods of solving problems in alternating current circuits states that the methods are analogous to those used in the graphical solutions relating to the composition and resolution of forces in graphical statics. It will be a great relief to the weary student when he learns that there exists a way of escape from the vortex of endless formulas and symbols.

Other chapters in order are: Armature windings for alternators; Self induction and capacity; The magnetic circuit of alternators; Characteristics and regulation; Efficiency; Mutual induction; Conservation of ideal transformer and effect of iron and copper losses; Design of transformers; Polyphase conducting system, and the measurement of power in polyphase circuits; Alternating current motors, and polyphase transformers.

The appendices discuss the application of Fourier's Series to alternating-current curves, the characteristic features of alternating-current curves, oscillatory discharges and electrical resonance.

The student of alternating machinery, who has the strength to struggle through the 729 pages of rigid mathematical discussion in this work, will doubtless be repaid by the satisfaction of having acquired a thorough knowledge of this one branch of electrical engineering.

A STATISTICAL ACCOUNT OF THE SEVEN COLONIES OF AUSTRALIA. 1895-96. By T. A. Coghlan, Sixth issue. Sydney, N. S. W., Government Printing Office. 8vo.; cloth; pp. 502; with map.

This is an exceedingly full statistical statement of the progress and present condition of the Australasian Colonies of Victoria, New South Wales, Queensland, South and Western Australia, Tasmania and New Zealand. Excluding the uncivilized native races the population of these seven colonies, or Australasia, in 1895, was 4,238,369. In 1861 this population was only 1,265,898, the rate of annual increase to 1895 being equivalent to 3.62%. The combined revenue of these colonies, for 1895-96, was £28,539,239, of which £9,294,062 came from railways and tramways, practically all owned by the State, and £2,226,212 came from postoffices and telegraphs. The debt of the colonies is, however, a very heavy one, amounting to £206,376,299; of which £128,197,705 was incurred in constructing and purchasing railways. The annual interest and charges upon the public debt is £8,765,000, while the net revenue obtained from public work constructed from the loan fund is only about £4,022,000, leaving the difference as a net liability per annum. At the present time there are about 13,814 miles of railway in operation, or about 1 mile to every 233 sq. miles of territory and to every 310 inhabitants.

Mr. Coghlan then takes up the detailed statistics for these colonies, the following being some of the more important heads: Political divisions, climates, education, commerce, railways, mineral resources, agriculture, pastoral resources, private and public finance, and local government. An appendix gives very full statistical tables for the separate colonies for the years 1861-95 inclusive.

As nearly one-half of the area of the Australian continent has an annual rainfall of less than 10 ins., an interesting portion of the report relates to the results of public and private effort in sinking artesian wells to supplement the surface water supply. This work was started in 1879 by the discovery of an artesian supply of water, at a depth of 140 ft., on the Kallara Run. The government then began a systematic search for water, and since 1884 the sinking of artesian wells has proceeded in a systematic manner under trained officers. Of these wells 48 are in New South Wales, with an aggregate daily flow of about 63 million gallons of underground water, and an average depth of 1,476 ft., though the wells range from 120 ft. to 3,093 ft. in depth. Eastern Queensland has 15 government flowing wells, with a total daily flow of 5,572,000 gallons, with one well yielding 3,000,000, coming from a depth of 1,371 ft. West of the coast range in Queensland there are 293 more flowing wells, yielding a daily output of 215,727,500 gallons, exclusive of pumping supplies. In South Australia a great part of which is very dry, wells are being successfully sunk in many different parts of the territory; and the government of Western Australia is now proposing to sink a line of wells in the direction of the Coolgardie gold fields. The experiments in well sinking in Victoria are not encouraging.

The diversity of railway gage, resulting from the independent action of the several colonies, is now causing much trouble in intercolonial railway communication. As illustrating what this means to the colonies it is stated that out of the total mileage in the seven colonies, 3,661 miles are laid on a 5 ft. 3 in. gage, 2,535 miles on 4 ft. 8½ in. gage, and 7,577 miles on a 3 ft. 6 in. gage. The importance of adopting a uniform gage before the colonies incur greater expense in construction is fully recognized; and the commissioners of New South Wales have recently suggested a standard gage of 4 ft. 8½ in., and that the whole of the other lines be altered to this gage at the national expense.

REPORT ON PUBLIC BATHS AND PUBLIC COMFORT STATIONS.—By the Mayor's Committee of New York City, New York. 8vo.; pp. 195, with many illustrations. Address Wm. H. Tolman, Secy., 105 East 22d St., New York city.

In July, 1895, Mayor Wm. L. Strong appointed William G. Hamilton, C. E.; Moreau Morris, M. D., and William H. Tolman, Ph. D., an advisory committee to continue the study of public baths and public comfort stations, already reported upon by the Committee of Seventy. This committee, in the volume before us, reports the result of its two years' study of the subject; and also reports that $200,000 was appropriated, on March 25, 1896, for public baths and comfort stations. The history of public baths is exhaustively treated, from Roman times to the practice in England and on the Continent and to their somewhat limited use in American cities. The importance of their introduction in greater numbers into the city of New York is made apparent by the statement that out of a total population of 255,033, covered by the committee's inspection, only 306 persons have access to bath rooms in the houses in which they live. The committee therefore especially recommends the erection of bathing houses in the tenement districts; and suggests a number of houses of moderate size and cost, similar to the Peoples' Bath planned by Messrs. J. C. Cady & Co., architects, and located on an ordinary city lot of 25 by 100 ft., as being preferable to two or three greater bathing establishments costing large sums of money. Public schools should also be equipped with baths when this is practicable, to be used by women during school hours and by the children after school hours and on Saturdays. There are now in New York 15 floating baths, between the Battery and 134th St., erected at an average cost of $13,000 each, with an aggregate annual cost for maintenance of $48,000. The Peoples' Bath House, in Centre Market Pl., near Broome St., is an attractive and substantial structure with inner wall of white enameled brick. It is fitted with complete sanitary appliances and 18 spray or shower baths, after the Vienna system. This is simply a shower of water regulated as to force and temperature by the bather, the water running off directly to the sewers. Its advantages are perfect cleanliness, no risk of infection, which is almost inseparable from the use of bath tubs, and a great economy of water, as six persons are able to efficiently bath with the water that would be used for one tub bath. A charge of 5 cts. is made for a bath, and the expense of operation beyond receipts last year was $669.22. The average number of bathers per month was 6,531, and from the date of opening, in 1891, 401,652 men, women and children have used it. Another bath house on the spray system has been built in New York from the Baron de Hirsch Fund, at a cost of $14,500, and is open to both Jews and Christians. The Riverside Association baths are also upon this system, the charge for a bath being 5 cts. in both of these latter institutions. Swimming baths are also recommended by the committee, and the operation of the London baths of this type is fully described.

The need of conveniences for public comfort has been long recognized in American cities, and several attempts have been made, with more or less success, to introduce the system into New York. With 1,232 acres of park area in New York, for example, and exclusive of over 2,700 acres of newly-instituted parks, there are just 18 public urinals; and 16 of these are in the East River Park, leaving only 2 in the 840 acres of Central Park. The large portion of the committee's report devoted to the discussion of this public necessity, and the provision made in other countries is, therefore, very pertinent, and should be studied with the interest it deserves. The committee recommends the underground latrines adopted by the City of London, as being practically self-supporting, not obstructing the streets and economical. The last latrine built in London cost $11,945, though in an exceedingly populous district. Plans are presented for these and for self-flushing urinals.

AMERICAN RAILWAY PRACTICE has been reported upon by a special German commission which recently traveled over about 8,000 miles of American railways. This official report is summarized by U. S. Consul Monaghan, of Chemnitz, and the general tendency of the report is much in favor of the American system, and the commission recommends its government to adopt many features which it believes to be superior to European practice. They contrast the New York Central express to Chicago, covering 969 miles in 20 hours, at an average speed of 48½ miles per hour, with the Ostend-Vienna express, averaging 35.3 miles; the Paris-Constantinople express, averaging 29 miles; the Calais-Brindisi express, averaging 34 miles, and the Paris-Nice express, averaging 39 miles per hour. The ordinary international trains are much slower than these, as the Berlin-Madrid trains average 28 miles, and the Berlin-Rome trains, 27.6 miles. The commission claims that this slow speed is greatly due to the limited capacity of European locomotives. Our baggage system admits 150 lbs. free to any passenger, as against 55 lbs. free for first-class passengers only on European lines. The commission admits the superior comfort of our form of cars, and also speaks approvingly of our baggage checking system, accident insurance, free time-tables, bureaus of information, etc.

THE GRAND CENTRAL STATION, New York city, is to be enlarged, and the plans for the new building have been prepared by Mr. Bradford L. Gilbert, architect, of New York. The interior arrangement will be considerably changed, and two stories will be added to the headhouse, increasing the area available for office purposes from 55,000 to 133,000 sq. ft.; the three waiting rooms for the three roads using the station will be replaced by one main waiting room, 100 × 200 ft., with an arched roof, and there will be baggage rooms, 30 × 144 ft. and 31 × 179 ft.; men's toilet room, 35 × 35 ft; women's room, 34 × 34 ft., with a toilet room 20 × 30 ft., and a smoking room 30 × 58 ft. The baggage will be carried in a subway under the platforms, with elevators to each platform. A power plant of 1,750 HP. will be installed for electric lighting of the station and yards.

A NEW RAILWAY STATION and office building is being built at Galveston, Tex., for the Gulf, Colorado & Santa Fe Ry. It is 100 × 120 ft., four stories high, of stone, red brick and terra cotta, with steel floor beams. There will be a general waiting-room, 100 × 52 ft., 35 ft. high; a women's waiting room, 25 × 28 ft.; ticket office, 14 × 25 ft.; also colored people's waiting-room, smoking, lunch and baggage rooms, and rooms for the superintendent, trainmen, etc. The upper floors will be for railway offices. The building will have 600 incandescent lights, exclusive of those in the train shed. The general plan of the yard and building was designed by Mr. C. F. W. Felt, Chief Engineer, and the architectural features are the work of Mr. A. J. Armstrong, architect. The contract for the work has been awarded to the Texas Construction Co., and the foundations have been completed.

THE FREIGHT SHED ROOFING at the freight terminals of the Pennsylvania Lines, at Columbus, O., described and illustrated in our issue of Feb. 4, is an asphalt and gravel roof made by the Consolidated Roofing Works, of Columbus. It is styled "Class B," and consists of single layers of felt sheeting, laid to lap 2 ins. at the joints and then cemented and nailed, after which the joints are covered with 4-in. strips of burlap, carefully cemented. Upon this surface is laid a course of screened sand and a thicker course of screened gravel, with 9 gallons of asphalt cement per 100 sq. ft. of surface. The weight is 275 lbs. per 100 sq. ft.

A TRACK FLAG for maintenance of way work is in use on the Erie & Ashtabula Division of the Pennsylvania Lines, and is smaller, lighter and cheaper than the one shown in our issue of Feb. 25. It is of ¼-in. iron, of triangular form, 4½ ins. high (including a ½-in. point), and 3¾ ins. wide on top, with top curves of 5-16-in. radius. Half the face is painted red and the other half white. The point is driven into the ties. This device is described to us by Mr. Karl J. C. Zinck, of the engineer corps of this division, at Newcastle, Pa.

THE ENGINEERS' CLUB OF PHILADELPHIA is discussing the advisability and possibility of combining with the Franklin Institute and with engineers, architects, and others interested in engineering matters, with the view of erecting a substantial building which will serve as a headquarters for societies of this kind and also provide offices for engineers and the representatives of iron manufacturers. The details of the proposed plan are to be made public later.

THE CARNEGIE STEEL CO. has opened an office in Victoria St., Westminster, London, and announces that from its London office it is ready to make sales for the delivery of its material to any part of the world outside of America. This looks as if the recent invasion of the "markets of the world" by American steel is to be followed by permanent occupancy. Both American and German steel bars are now being used by the Welsh tinplate makers.

AN ABSOLUTE VACUUM, or what is believed to be one, was recently produced by Prof. Elmer Gates, of Washington, by a novel method. Into a test tube made of a kind of glass which melts at a very high temperature he poured a molten glass which melts at a much lower temperature, completely filling the tube, leaving no air space. After melting this inner glass it was partially withdrawn from the tube by exhausting the air from the outer side and allowing it to flow down by gravity but not so far but that the end of the tube was completely closed. It was then allowed to cool. As no air could enter the space left by the withdrawal of the glass, it is believed that a perfect vacuum was obtained.